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STUDIES ON THE BRITISH WHITE-FLIES (HOMOPTERA, ALEYRODIDAE)

By K. N. Trehan, M.Sc. (Punjab); Ph.D. (London).

(*Department of Entomology, Rothamsted Experimental Station, Harpenden.*)

With Seven Text-figures.

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Introductory.

Little has been added recently to the knowledge of the British Aleyrodidae with respect to their morphology, habits and food-plants. Their systematics have been equally unsatisfactory, and since the descriptions were inadequate in affording positive diagnostic characters, the position of some species was as undefined as it was about fifty years ago.

Since the correct determination of a species is important to the entomologist, and a knowledge of its biology is essential before undertaking control measures, these investigations were made to throw some light on the available species.

The comparative morphology was studied and some of the previous specific characters have proved to be of little significance. The identity in some of the species was established by their structural uniformity as well as by transference to alternative host-plants. These when successful confirmed the identity and also eliminated the possibility of the existence of biological food races. Two new species have also been described from ferns in the Royal Botanic Gardens at Kew (Trehan 1938).

Observations have also been made on parasites and parasitisation in some of

the species, and cross inoculations were tried to breed a parasite from one host on another.

The present investigations were continued from October 1936 to May 1938, under the supervision and guidance of Dr. C. B. Williams, the Chief Entomologist at the Rothamsted Experimental Station.

Acknowledgments.

I consider it my privilege to express my deepest gratitude to Sir John Russell, the Director of the Institution, for the facilities provided even to the extent of the use of his private garden and plants for field experiments. I am equally indebted to Dr. C. B. Williams for his keen interest in the problem and for going through the manuscript; to Dr. H. F. Barnes and Dr. A. C. Evans for their general assistance.

The assistance of Mr. F. Laing and Dr. Ch. Ferrière of the British Museum (Natural History), and the help of Mr. G. Fox-Wilson and Dr. A. M. Massee for the supply of some material, are gratefully acknowledged.

The generosity and the encouragement of the Indian Central Cotton Committee by the grant of a foreign scholarship for higher study, is also highly appreciated.

Review and comments on some of the previously adopted characters and the significance of those now adopted.

Previous authors based specific differentiation on certain variable characters such as the food-plant, colour and shape of the body, and number of hairs and proportion of the antennal segments, but it has been now ascertained that the variations common in such characters were totally ignored: therefore, such criteria have often led to synonymy and to no organised system of classification. Prior to the standard work by Quaintance and Baker (1913–14) morphological characters in ALEYRODIDAE were not studied thoroughly. Burmeister (1835) and Westwood (1840) considered the antennae to be of six segments. Ruricola (1846) even doubtfully stated them to have five segments. Koch (1857) noted the parameres (forceps), which are a stable character in the family, for the first time in the male of *A. lonicerae*. Signoret (1868) gave a curious description of lingula which he noticed only in the adult of *A. rubi*— " tubercle more or less elongated and vesicular visible in both sexes, more in female " [translated]. Douglas (1891 and 1895) gave an interesting interpretation of the vasiform orifice in the pupae of *A. rubicola* and *A. carpini*.

The vasiform orifice is a most specialised organ in this family and exists in all stages after the egg. Maskell (1895) first recognised its importance and stated ". . . I have noted specific variations in this organ and believe it quite a valid differentiating character." Peal (1903) also considered it a strong character for the species. Quaintance (1908) stated " these structures vary much with different species and consequently furnish valuable diagnostic characters." Quaintance and Baker (1913–14, 1917) and Baker and Moles (1921) emphasised the importance of this organ in classifying the genera of the world.

The genitalia in insects are also recognised to possess certain permanent features which differ with the species. Kirkaldy (1907) regarded the genitalia in the male as the final test of a species and even as affording generic criteria. Muir (1916) placed considerable significance on the aedeagus and the male genitalia of DELPHACIDAE. Giffard (1921) remarked that " because of their

constancy and reliability as a specific character these organs are unquestionably of first importance to the student in making correct determinations." Singh Pruthi (1925) stressed the importance of these organs in the classification of JASSIDAE. Snodgrass (1931) considered these organs to give the best characters by which species may be distinguished, and, similarly, Delong and Davidson (1937) considered the chitinous parts of the genital chambers as the most important structures for the separation of species.

Attempts were therefore made during the present investigation to make a comparative study of both the vasiform orifice and genitalia which have given quite significant differences. It is therefore believed that these organs give far more reliable specific differences than any other characters. In certain cases, however, some other characters may also contribute some supplementary evidence.

Technique.

For descriptive purposes the stages of the various species were reared under observation but occasionally were also obtained in the field, and mounted in Berlese's fluid. For the study of the genitalia and finer details the specimens were treated with 10% KOH solution and then neutralised in 2% solution of acetic acid in 90% alcohol and ultimately mounted in balsam.

Aleyrodes lonicerae Walker 1852 and *A. rubi* Signoret 1868.

Walker (1852) described *A. lonicerae* from *Lonicera periclymenum* (Honeysuckle), giving a brief account of the coloration of the adult and pupa. Koch (1857) described the same species, but the colour of the adult does not agree with the original description. Frauenfeld (1867) supported Walker and stated Koch's *lonicerae* is not Walker's *lonicerae*. Signoret (1868) disagreed with Koch in considering the " forceps " in any way specific to this species. At the same time, he laid considerable stress on the number and distribution of the dorsal spines on the larva. Douglas (1896) contributed for the first time a description of its pupa. His description included a brief mention of the size and shape of the " triangular formation," which is most probably the vasiform orifice. Further, he doubted Walker's description of the colour of the pupa and described it as deep golden yellow.

Since then the species has remained neglected except for a few casual references. Quaintance and Baker (1914) assigned to it a generic position under *Aleyrodes*, and Harrison (1920, 1931) and Marriner (1931) gave an account of its distribution in the north of England. Deshpande (1933) published a brief account of the various stages of this species and showed that the eyes in *A. lonicerae* are similar to those in *A. rubi*. Further, he described two kinds of pupae in *A. lonicerae*—one with the dorsum apparently smooth and the other with six pairs of dorsal spines. The colour of the pupa is described as " olive-yellow." Deshpande also stated that, " in this species there are also specimens which are quite yellow without any dark colour on the body except one black mark on the wings. But there is no difference in the general structure."

Signoret (1868) described *A. rubi* from *Rubus fruticosus* (Blackberry) and gave a detailed description of the colour of the adult and a short account of the larva. It was remarked that the distinguishing characters between these two species (*A. lonicerae* and *A. rubi*) exist in their larvae. He stated, " The larva resembles that of *A. lonicerae*, showing the same bristles at the same place, only on the median line one observes at each abdominal segment, a distinct area (impression) which is more visible at the base than at the apex " [translated].

On the other hand, Douglas wrote of *A. lonicerae* " . . . the segmentation of the abdomen is evident, also there is a median row of concolorous raised spots." Evidently there appears to be a different interpretation of one and the same fact.

The table below summarises the descriptions of these species by the respective authors, from which it will be evident that there is little appreciable difference on which to consider them as distinct species. Signoret, while describing *A. lonicerae*, missed the item 9, which otherwise was regarded as quite a distinctive character in separating the species. Douglas, however, cleared up the doubt by pointing out this feature in *A. lonicerae* (Table I).

TABLE I.

Brief remarks from the descriptions of *A. lonicerae* and *A. rubi*, by Douglas and Signoret.

A. lonicerae (Douglas)	*A. rubi* (Signoret)	*A. lonicerae* (Signoret)
1. Abdomen yellow.	1. Yellow, spotted with blackish-brown.	1. Yellow, spotted with blackish-brown.
2. Head black, yellowish at sides.	2. Head almost entirely black, cheeks yellow.	2. No mention.
3. Thorax grey-black, margins pale.	3. Thorax and chest more or less black, sutures more or less pale.	3. Black spots on pro- and meta-thorax, base of abdomen blackish.
4. Eyes brown, divided.	4. Eyes reddish-brown, very divided.	4. No mention.
5. Antennae pale brownish.	5. Antennae brownish.	5. No mention.
6. Thighs black, extremities yellowish, tibiae yellowish, extremities black, tarsi black.	6. Feet black except the articulations more or less pale.	6. No mention.
7. Wings white with one grey spot in elytra at the end of the median nervure.	7. Elytra with a single black spot.	7. Single spot in elytra at the apex of the vein.
8. Larva with six pairs of hairs.	8. Larva: same arrangement of bristles as found in *A. lonicerae*.	8. Larva with six pairs of bristles.
9. Larva with concolorous median row of round spots.	9. Each abdominal segment in larva has an "impression" on the median line.	9. No mention.

The supposed differentiating characters between the so-called distinct species, therefore, were regarded as their food-plants and as a minute structural difference in the larvae. Moreover, colour and the description of the pupa in *A. lonicerae* have been the subject of considerable controversy and conflicting opinions have been expressed. It is now known that this may be the result of collecting specimens at different times of the year.

Present Observations.

To verify the supposed structural differences in both species, their morphology was studied critically and the biology investigated both in the field as well as in the laboratory. The distinct areas stated to be present in the median abdominal line of the pupa in *A. rubi* are also met with in the pupa of *A. lonicerae*.

Pupae of two types have been observed in nature: (1) white, (2) yellow or even tending to golden yellow. Therefore, the description of the pupa by Walker is not wholly incorrect. His description was probably based on the examination of a few specimens, particularly from the summer brood, and thus a complete range of variations was not studied. At the same time, the descriptions by Douglas and Deshpande were also based on restricted observations.

As regards the presence and distribution of dorsal spines on pupae, Douglas remarked " the dorsal hairs of the larva have mostly disappeared but a few of them are persistent in some specimens." The statement is true, but is unsatisfactory because a complete range of variations in this respect was not studied. Similarly the views expressed by Deshpande as to the two kinds of pupae require further explanation. Apart from the specimens falling in group no. (1), no strict arrangement in the number of spines has been observed. On the contrary, considerable variation has been noticed in their number from an apparently hairless form to a full complement of seven pairs of spines. This, however, is not contrary to expectation as it has previously been noticed in *B. gossypiperda* by Husain and Trehan (1933) and by me again in *A. carpini.*

The present observations may be summarised thus :—

1. *Colour of the pupa* (*A. lonicerae* type).

(A) White—very common during summer, after which the number decreases considerably.

(B) Yellow—tending to golden yellow—during autumn, winter and early spring; almost absent in summer.

2. *Number and distribution of dorsal spines* (Table II).

i. Full complement of seven pairs—1 cephalic, 3 thoracic, 2 abdominal and 1 vasiformal.
ii. Six pairs—abdominal pair single.
iii. Five pairs—one thoracic pair missing; occasionally asymmetry may be noticed.
iv. Four pairs—abdominals missing.
v. Three pairs—only a single thoracic pair and the abdominals missing.
vi. Practically hairless—a few minute hook-like spines visible.

The arrangement cited above equally describes the pupae on blackberry—hitherto known as *A. rubi*, except for the condition mentioned under vi.

TABLE II.

Variations noted in the number, distribution and development of dorsal spines in *A. lonicerae* (III instar and pupa) on respective food-plants.

Instar	*A. lonicerae* on Honeysuckle (*Lonicera periclymenum*)					Instar	*A. lonicerae* on Blackberry (*Rubus* sp.)				
	Pairs of dorsal spines						Pairs of dorsal spines				
	Total no. of pairs	Antennal	Thoracic	Abdominal	Vasiformal		Total no. of pairs	Antennal	Thoracic	Abdominal	Vasiformal
III	3	1++	0	1++	1+	III	3	1++	0	1++	1+
	3	1+	0	1−−	1−−		3	1++	0	1+	1+
	3	1−−	0	1−−	1−−		4	2++	0	1++	1+
	3	1+	0	1+	1−		5	2++	0	2++	1+
	4	2+	0	1+	1+		9	2++	3++	2++	2+/++
	5	2+	0	2−/+[1]	1+						
Pupa	3	1++	1−	0	1−−	Pupa	3	1++	1++	0	1++
	3	1−−	1−−	0	1−−		4	1+	2+	0	1+
	4	1++	2−/+[1]	0	1−		5	1++	3−/++[1]	0	1+
	4½	1++	2++[2]& ½−−	0	1++		5½	1++	3−/++[1]	½+[2]	1++
	5	1++	3++	0	1++		6	1++	3++	1++	1++
	6½	1++	3½++[2]	1+	1+		7	1++	3++	2+/++[1]	1++

− Minute. −− Very minute. + Developed. ++ Well developed.

[1] Asymmetry in development. [2] Asymmetry in numbers.

The adult of this species has always been described as grey in colour. During the present investigations, however, two types of adults were met with : (1) yellow, without any markings on the body except a black spot on the wings, (2) grey, showing considerable dark brown markings on the body besides those on the wings. The seasonal colour variations have been described by Trehan (1939).

The morphology of all the stages of *A. lonicerae* was studied and compared with that of the respective stages of *A. rubi*. The general structure in both these forms agrees in all details and the two are absolutely inseparable morphologically.

The previous differentiating characters have been proved to be of least significance because of the variations in dorsal spines as well as in the colour of the pupae and adult. The identity of the two forms is concluded on the evidence of the identical nature of the vasiform orifice in their respective stages as well as by the genitalia. The characteristic notch towards the distal end of the parameres with its claw-shaped ending and the heel-shaped structure sub-apically are quite identical in both the forms. In the female also the genitalia are alike.

This was further supplemented by the comparative study of other characters such as the eyes, antennae and wings of adults. All these characters agree remarkably in their structure in both forms. Nevertheless, some variations have been observed in the measurements of the antennal segments in different sexes as well as in individuals, but these were equally applicable to both the forms. For instance, segment VII is the longest of the distal four segments, but variations have been noticed in its measurements and occasionally segment V approaches it in length. Because of the pronounced variations, specific differentiation is not justified on superficial characters.

Biology and breeding tests.

Biology. The first record of an adult on honeysuckle was on 1.vi.1937, from Batford, Herts. The body colours were fully developed. The adults were quite scarce after that, but a few eggs were also noticed on honeysuckle, at Bricketwood, Herts, on 15.vi. In the first week of July, at Batford, Herts, besides a number of nymphs in the 2nd and 3rd instar, 8 pupae and 7 adults were also collected from honeysuckle. These adults were of the yellow type and the presence of a few pupa cases indicated that the first generation was over. The pupae were of white colour and the adults which emerged from them, in the laboratory, were also yellow. Since then both the pupae and the adults were frequently met with on honeysuckle—the adults being yellow and the pupae white.

Towards the middle of July eggs were noticed both on honeysuckle and on blackberry, though relatively fewer on the latter. Comparative counts on the 22.vii. gave 339 eggs on 60 leaves of honeysuckle against 103 on 40 leaves of blackberry. An average leaf of blackberry is, however, relatively larger than one of honeysuckle. The number of eggs laid on individual leaves varied from 1 to 9 on blackberry and 1 to 21 on honeysuckle. The adults of the yellow type were common on both the host-plants.

It is presumed that feeding of the first brood commences on honeysuckle, from where the pest migrates to blackberry. The relative infestation in nature, therefore, was found to be higher on honeysuckle. The probable cause of this variation in infestation is in the relative difference in the leaf area of the respective hosts, or the result of some constitutional changes in them as previously studied by Husain, Puri and Trehan (1936).

Series of observations on the sex ratio during July to November, 1937, at two widely separated localities gave the following figures :—

	Batford	Bricketwood
Total catch	303	403
Females	210	288
Males	93	115
Percentage of females . . .	69·3	71·4

Average percentage of females 70·5.

The adults are long lived, and therefore the generations overlap. During November, only females were observed in the field. During autumn the adults were frequently observed taking shelter under the leaves of small oak bushes. In no case, however, was any egg or nymph observed on them. It is therefore presumed that such a coincidence probably led Signoret to describe the adults of *A. quercus* (from oak) as grey and the description practically corresponded with that of adults of *A. lonicerae*. A few overwintering females from the laboratory stock when shifted to a hot-house during March and April 1938, laid eggs readily. It is, therefore, quite probable that such individuals may start oviposition in nature as soon as the favourable period approaches. Overwintering in the pupal stage is also common.

Life-history. In nature egg-laying is very heavy during the summer but decreases considerably towards the end of September and may even stop later. The eggs, as a rule, are laid singly. The area frequented by the adult becomes conspicuous by the presence of a white waxy powder in the centre of which lies an egg which is also dusted profusely. Occasionally, however, two eggs are noticed close together. The females are easily disturbed when in the act of oviposition. It has been repeatedly observed that the eggs may not turn brown before hatching.

TABLE III.

Life-cycle and cross inoculations of *A. lonicerae*, on alternative food-plants, 1937.

Adults from	Life-cycle completed on	Date of introducing the adults	Earliest date of hatching of eggs	Earliest date of 1st moult	Earliest date of pupation	Earliest date of emergence	Shortest duration of the life-cycle in days
		1937	1937	1937	1937	1937	
Lonicera periclymenum [7]	*Lonicera periclymenum*	1.vi.[1]	12.vi.	—	—	—	—
Lonicera periclymenum	*Lonicera periclymenum*	6.vii.	19.vii.	1.viii.	23.viii.	29.viii.	54 [4]
Symphoricarpos racemosus [8]	*Symphoricarpos racemosus*	6.vii.[2]	20.vii.	3.viii.	25.viii.	1.ix.	57 [4]
Rubus fruticosus [9]	*Lonicera periclymenum*	9.vii.	21.vii.	3.viii.	26.viii.	29.viii.	51 [4]
Lonicera periclymenum	*Symphoricarpos racemosus*	13.vii.[2]	27.vii.	9.viii.	—	10.ix.	59 [4]
Lonicera periclymenum	*Symphoricarpos racemosus*	16.vii.[2]	3.viii.	—	—	8.x.	84 [5]
Lonicera periclymenum	*Rubus fruticosus*	23.vii.	4.viii.	10.viii.	—	8.ix.	47 [6]
Rubus fruticosus	*Lonicera periclymenum*	30.viii.	14.ix.	22.ix.	12.x.	19.x.	50 [6]
Lonicera periclymenum	*Rubus fruticosus*	31.viii.	15.ix.	—	12.x.	19.x.	49 [6]
Lonicera periclymenum	*Lonicera periclymenum*	9.ix.[3]	—	—	—	21.x.	42 [6]

[1] The plant as it was transplanted, dried up, and the nymphs did not develop into adults.
[2] Breeding was on plants growing in nature, in a very shady corner of a garden.
[3] In hot-house.
[4] Parents yellow, offsprings : males yellow, females grey.
[5] Parents yellow, offsprings all grey.
[6] Female parents grey, offsprings all grey.
[7] Wild honeysuckle.
[8] Snowberry.
[9] Wild blackberry.

The species is multi-brooded and the generations overlap. During 1937, the shortest duration of the egg stage, observed under field conditions, varied from 11 to 18 days. The shortest duration of the nymphal stage was 27–36 days and that of the pupa 6–7 days (Table III).

Cross inoculation. The adults bred from the pupae on respective food-plants were sleeved on alternative food-plants. Thus the adults from honeysuckle were bred on snowberry and blackberry as well as those from blackberry on honeysuckle. To verify the duration of the life-cycle, the adults were also bred on their respective food-plants. These inoculations were quite successful and the life-cycle durations were almost unaffected, as is shown in Table III.

Alternative hosts. The adults have been collected from oak and hazel in large numbers and even from strawberries during autumn. None of these, however, is regarded as a true alternative host because immature stages were not obtained on them in the field.

During March and April 1938, the following observations were made in a hot-house :—

(1) Adults of *A. lonicerae* were sleeved on strawberry, where eggs were laid and the nymphs flourished very well. The life-cycle was completed in about 47 days.

(2) Adults of *A. lonicerae* were allowed to breed on oak leaves. Most of the adults were found dead in about three days. In one case eggs were not laid; in another only two eggs were laid, while in the third case five eggs were noticed. These eggs did not hatch.

This species has been observed breeding freely on snowberry[1] (*Symphoricarpos racemosus*) and on french-willow herb (*Epilobium augustifolium* L.). These plants, therefore, are an addition to the list of the known food-plants.

Description of the stages of Aleyrodes lonicerae *Walker* (figs. 1, 2).

Egg. Oblong, pedunculate, chorion smooth; yellowish-white, dusted profusely with white waxy powder, average measurements 0·27 × 0·10 mm.; stalk about 0·03 mm.

Nymph 1st instar. Elliptical, pale yellow, margins surrounded by a waxy fringe; average measurements 0·35 × 0·20 mm. Marginal spines sixteen pairs; dorsal spines three pairs—antennal, abdominal and vasiformal, only the antennal pair slightly better developed. Occasionally, however, more spines may be met with; ventrals 3 pairs—cephalic, rostral, and vasiformal. Antennae three segmented, 3rd the longest of all and provided with two spines, average length about 0·09 mm. Eyes divided; legs functional. Vasiform orifice subcordate (fig. 1), average measurements 0·03 × 0·04 mm., inner lateral and caudal margins not thickened, posterior margin slightly notched; operculum almost rectangular, measuring, on an average, 0·01 × 0·03 mm., caudal margin with a few minute hairs; lingula thick and almost cylindrical, setose with 4 prominent hairs shooting out from the distal half, length 0·02 mm. and more than ¾ exposed beyond the operculum.

Nymph 2nd instar. Pale yellow; oval, margin lightly dentate, surrounded by a narrow waxy fringe, average measurement 0·52 × 0·32 mm. Marginal spines three pairs, the anals prominent; dorsal spines 2–6 pairs; ventrals 1–4 pairs, generally minute. Eyes entire; legs degenerate; antennae atrophied, directed backwards, average length 0·02 mm. Abdominal segments marked by a series of concolorous tubercles on either side of the median line. Vasiform orifice subcordate, average measurements 0·04 × 0·05 mm.; inner lateral margins slightly roughened, caudal margin slightly notched; operculum sub-rectangular, lateral margins curved, average measurements 0·02 × 0·04 mm.; lingula short and thick spatulate, setose all over and armed distally with a pair of long hairs (fig. 1), average length 0·02 mm.; about ¾ exposed beyond operculum.

[1] Dr. C. B. Williams thinks that he has seen an old record of a white-fly on snowberry, but the reference was not traced.

Nymph 3rd instar. Shape and colour as in the previous instar; average measurements 0·73 × 0·50 mm.; abdominal segments marked by a series of concolorous tubercles on either side of the median line. Marginal spines three pairs—the anals being prominent; dorsal spines 3–4 pairs, variable; ventrals 1–2 pairs, minute. Eyes entire; legs degenerate; antennae atrophied, directed inwards, ending distally in a hook. Vasiform orifice subcordate, average measurements 0·05 × 0·06 mm.; inner lateral margins slightly roughened, and the caudal margin notched; operculum sub-rectangular, average measurements 0·02 × 0·05 mm.; lingula setose all over and armed distally with a pair of long hairs; average length 0·03 mm.

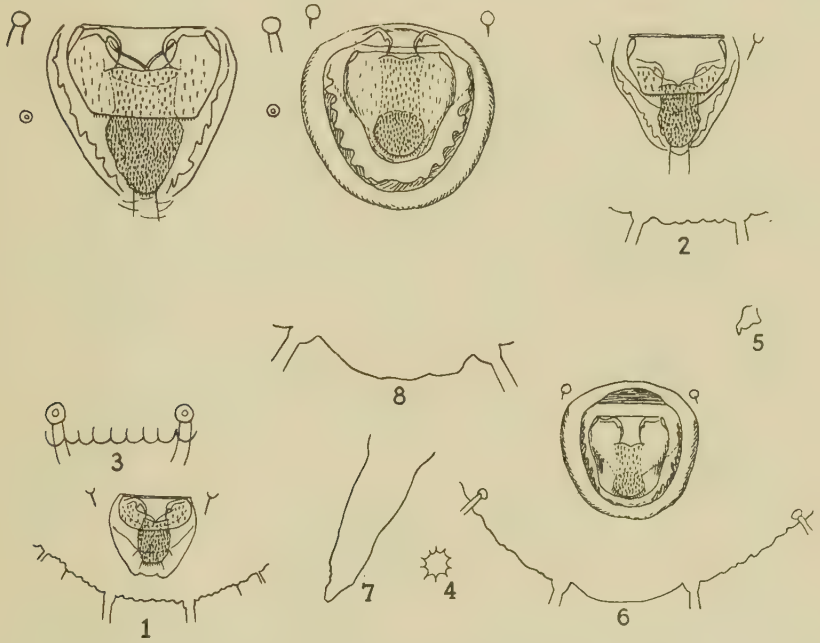

FIG. 1.—1–3, *A. lonicerae*, 1, vasiform orifice of 1st instar larva; 2, vasiform orifice of 2nd instar larva; 3, vasiform orifice of pupa; 4–8, *T. ericae*, 4, star-shaped structure on larva; 5, antenna of 3rd instar larva; 6, vasiform orifice of 3rd instar larva; 7, antenna of pupa; 8, vasiform orifice of pupa.

Pupa. Oval, ultimately becoming opaque and convex dorsally, colour variable between white, yellow or golden yellow; average measurements 1·05 × 0·74 mm. Margins dentate, surrounded by a thick rim of wax. Submarginal area transversely striated. Abdominal region marked usually with a row of concolorous tuberosities in the median line. Marginal spines three pairs—the anals prominent; dorsal spines 3–7 pairs, varying in size and distribution; ventrals may be absent. Legs degenerate; antennae, directed backwards and outwards, ending distally in a minute process, length about 0·07 mm. Vasiform orifice subcordate, average measurement 0·07 × 0·07 mm., inner lateral margins roughened, caudal margin slightly notched; operculum sub-rectangular, the caudal margin minutely hairy; average measurements 0·03 × 0·05 mm.; lingula cylindrical, thick and spatulate, setose all over, armed distally with a pair of long hairs; average length 0·05 mm., about ⅔ exposed beyond the operculum (fig. 1).

Adult [2]—*Female.* Yellow, spotted with grey; head dark, mesothorax with one median,

[2] The descriptions, with the exception of the colour, apply both to grey and yellow individuals.

and two lateral spots, metathorax with a pair of median pear-shaped dark brown spots. Abdomen yellow, with a few faint (sometimes very conspicuous) transverse bands of brown, margins of the wax plates dark; last abdominal segment dark both dorsally and ventrally—leaving a circular yellow patch on the ventral side. Wings with one cloud distally, margins beset with a series of minute spines (fig. 2). Eyes divided, the halves separated by a streak, lower facets relatively larger and arranged in hexagons (fig. 2). Antennae darker distally, seven segmented (fig. 2), the 3rd the longest and provided with 3 sensoria distally, IV cylindrical, the smallest; V club-shaped with one sensorium near the tip; VI cylindrical, elongated; VII tapering abruptly, provided with a sensorium and a spine apically;

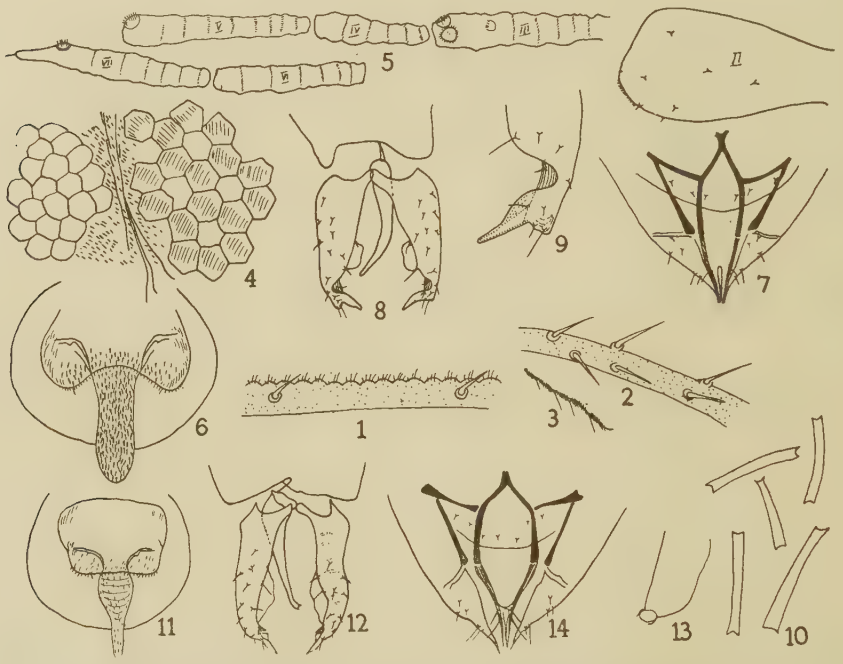

Fig. 2.—1–9, *A. lonicerae*, 1, costal margin of fore-wing; 2, costal margin of hind-wing; 3, lower margin of hind-wing; 4, eye of adult; 5, antenna of adult female; 6, vasiform orifice of adult female; 7, genitalia of female; 8, genitalia of male; 9, tip of a paramere; 10–14, *S. phillyreae*, 10, wax tubes on pupa; 11, vasiform orifice of adult female; 12, genitalia of male; 13, tip of aedeagus; 14, genitalia of female.

segments III–VII imbricate, measurements variable even within individuals. Vasiform orifice almost sub-circular, measuring, on an average, 0·07 × 0·08 mm. (fig. 2); operculum broad and sub-rectangular, caudal margin deeply notched, and hairy, average measurements 0·04 × 0·06 mm.; lingula long and stout, rounded at the tip, setose all over, almost entirely exposed, average length 0·04 mm. Genitalia as usual in the family, basal region of the inner valves provided with a single pair of prominent hairs (fig. 2).

Male. Colour may be lighter than the female. Vasiform orifice and the antennae correspond with those of the other sex, aedeagus curved, but not angulate. Parameres broader at the base, distally the inner margin is tucked into a notch forming a characteristic claw-shaped end with a basal heel armed with a pair of prominent bristles (fig. 2); length about 0·14 mm.

Aleyrodes carpini Koch 1857 and *A. rubicola* Douglas 1891.

These species have been regarded as distinct since they were first described, although no serious attempts have been made to examine them critically.

A. carpini was recorded originally by Koch (1857) from *Carpinus betulus* (hornbeam), and the colour of the adult was described. This, however, did not appeal to Frauenfeld (1867). Signoret (1868) simply copied the original description, but Douglas (1895) redescribed the adult and supplemented the description by a brief account of the pupa.

As a result of the extremely poor knowledge of this species, Quaintance and Baker (1914) could not even assign it a generic position in their classification of the ALEYRODIDAE. Harrison (1920) first introduced it under *Aleyrodes*, but soon after placed it under the genus *Asterochiton*. Marriner (1931), supported by Laing, disagreed with this change in generic position.

A. rubicola, on the other hand, was described by Douglas (1891), who recorded it from blackberry. His first attempt to distinguish it from *A. carpini* was based on its association with a different food-plant. He stated, "It is far more in agreement with *A. carpini* Koch; that species, however, has hitherto been believed to be special to hornbeam. The present form, I believe, is distinct; I name it provisionally *A. rubicola*." Towards the end of the same year he confirmed his views and described briefly the various stages, giving a few sketches. In the absence of any description of the immature stages of *A. carpini*, of which Douglas had no personal knowledge at that time, he anticipated that corresponding differential structures may exist even in their larvae. Since then the species has not been studied critically, and Quaintance and Baker (1914) classified it wrongly.

Presumably, therefore, these species were kept distinct on two characters: (1) the association of the forms with different food-plants, (2) on the relative proportion of the antennae which were stated to differ from the original diagram by Koch.

Present Observations.

The description of the various stages given under *A. carpini* practically agree with those found on blackberry. Observations in nature, as well as in the laboratory, have yielded conclusive data for regarding them as identical. This conclusion is based on the study of the following aspects:—

1. *Morphology.*
   - i. Lack of significance of the previously supposed differences.
   - ii. Special reference to the structure of the vasiform orifice in all the stages.
   - iii. Study of the genitalia of the adult.

2. *Biology.*
   - i. Appearance of the adults and their sex ratio.
   - ii. Life-history and breeding tests.
   - iii. Cross inoculations.

1. (i) The sketches of antennae given by Koch under various species of *Aleyrodes* are almost all open to criticism and are practically without exactitude. Douglas also submitted an equally inaccurate diagram with his description of the species *A. rubicola*. The antennal segment VII is shown quite blunt and without a terminal spine, also segment IV has been represented as almost a square. This is contrary to the actual structure (fig. 5). Similar inaccuracy

is noticed in his drawing of the " mature larva or pupa " of *A. rubicola*, in which the thoracic tracheal folds are represented but the caudal one is not shown. At the same time, no reference to either of these is given in the text, although these structures are very prominent in the pupa (figs. 3 and 4).

2. *Variations in spines.* Douglas, in his description of the " immature larva," stated " the *six* dorsal hairs are specially characteristic," but this is not a permanent character, as individual variations have been noticed in specimens collected in the field and bred in the laboratory.

The following arrangements have been met with in *rubicola* :—

Nymph 1st instar.

i. Marginals, 17 pairs as described under *A. carpini.*
ii. Dorsals, 3 pairs, antennal, abdominal and vasiformal, generally very minute, and occasionally more than three pairs may also be present.
iii. Ventrals, 1–3 pairs, near the orifice but considerable variations in size have been noticed in these.

Nymphs 2nd and 3rd instar.

Marginal spines are reduced to 3 pairs only, cephalic minute, caudo-laterals small and the anals developed as referred to under *A. carpini.*

On the other hand, considerable variations have been noticed in the dorsal and ventral spines in these instars and the various combinations are represented in Table IV.

A remarkable feature observed in this connection was the development of spines even on *A. carpini* type when bred on blackberry. On the contrary, the spines almost disappeared even on *A. rubicola* when these were bred on hornbeam. It may therefore be concluded that probably the food-plant plays an important part in bringing about these variations. Deshpande (1933) discovered a corresponding effect of the food-plant on the pupae of *A. lonicerae.* Takahashi (1933) also noticed that the pupae of *Acanthaleyrodes callicarpae* Tak. and other species which were associated with hairy leaves developed dorsal spines.

Douglas, in his account of the " mature larva " of *A. rubicola*, mentions certain notches or constrictions of the margin. My investigations have shown that these irregularities in the pupal form are only associated with the presence of hairs or some roughening on the leaf. In the absence of any of these, the larvae present quite a regular outline. Further, these folds have not been observed to show any definite arrangement and may vary in number and position with individuals.

ii. *Structure of the vasiform orifice.* This character seems to be very significant in showing the morphological identity of the forms as is evident from fig. 3.

The shape of the component parts of this organ in 1st instar nymphs of both so-called species is quite identical and the characteristic latero-posterior notches from the operculum are quite significant. The average measurements in *A. rubicola* type compare almost exactly with those of *A. carpini.*

In the 2nd instar, as well, the shape and structure are identical in both forms. Average measurements in *A. rubicola* type are almost equal to that in *A. carpini.* The inner lateral margins of the vasiform orifice are similarly thickened.

In the 3rd and pupal instars, the average measurements are alike and the operculum and lingula in both are brownish, the inner lateral thickenings in the vasiform orifice even extend medially and the floor is also thickened.

This organ presents quite identical characters even in the adults. The free margin of the operculum is slightly notched and the lingula is short and thick with a characteristic rounded tip.

Table IV.

Types of distribution and development of dorsal and ventral spines met with in the nymphs of *A. carpini* on *Rubus* sp. (*rubicola* type).

1st instar

No.	Dorsal											Ventral		
	Antennal Pairs				Abdominal Pairs					Vasiformal Pairs		Vasiformal Pairs		
	I		II		Anterior				Posterior					
					I		II							
	1	2	1	2	1	2	1	2		Anterior	Lateral	Anterior	Lateral	Posterior
1	– –	– –	+ +	+ +	– –	– –	+ +	+ +	+ +	– –	– –	+	+	+ +
2	– –	– –	○	○	– –	– –	○	○	○	– –	– –	○	○	○
3	– –	– –	○	○	– –	– –	○	○	○	– –	– –	○	– –	○

2nd instar

No.	Dorsal						Ventral					
	Antennal		Abdominal		Vasiformal		Antennal		Abdominal		Vasiformal	
	1	2	1	2	1	2	1	2	1	2	1	2
1*	– –	– –	– –	– –	– –	– –	○	○	○	○	○	○
2*	– –	– –	– –	– –	– –	– –	○	○	○	○	– –	– –
3	+ +	+ +	+ +	+ +	+	+	○	○	○	○	– –	– –
4	+ +	+ +	+ +	+ +	+	–	○	○	○	○	– –	– –
5	+ +	+ +	+ +	+ +	+ +	+ +	○	○	○	○	– –	– –
6	+ +	+ +	+ +	+ +	– –	– –	○	○	○	○	○	○
7	+ +	+ +	+ +	+ +	–	–	○	○	○	○	○	○
8	–	–	+ +	+ +	– –	– –	○	○	○	○	○	○
9†	+ +	+ +	+ +	+ +	+ +	+ +	+	+	+	+	+	+
10	+	+	+ +	+ +	– –	– –	○	○	○	○	○	○
11	+	+	+ +	+	– –	– –	○	○	○	○	○	○
12	+	+ +	+	+ +	+	+	○	○	○	○	– –	– –
13	+	+	+	+	– –	– –	○	○	○	○	– –	– –

– Minute. – – Very minute. + Developed. + + Well developed. ○ Absent.

* Bred on hornbeam.

† Two pairs of ventrals, one anterior and the other posterior to vasiform orifice, both developed.

iii. The genitalia in both male and female are identical and the description given under *A. carpini* fits nicely to the other form as well.

The structure of the eyes and antennae of the adults gave further evidence in support of their identity. The eyes are identical in structure, since the two halves in both the forms are connected by a bridge of one facet only (fig. 5). Correspondingly, the antennal segments also are of almost identical shape. Segment IV, however, differs strikingly in shape from that shown by Douglas.

In view of the uniformity in these morphological characters both in the larvae and the adult, it is recognised that both forms are indistinguishable from each other.

2. *Biology.*

i. *Appearance of the adults and their sex ratio.* The earliest adult, in nature, was collected on 20.v.1937 on hornbeam, after which the number increased in the field. Their distribution, however, was restricted to certain localities both on hornbeams and blackberries. Observations during May and June showed that the females considerably outnumber the males, and, on an average, were estimated at about 75% of the total catch. The adults, as a rule, are short-lived and their numbers show a pronounced decrease towards the end of June, when only a few stray specimens may be collected in the field. During 1937 adults were not observed in nature from July onwards.

ii. *Life-history.* Eggs are laid on the underside of the leaves, but may be noticed casually on the upperside as well, both in nature and in captivity. In nature they are laid scattered, and seldom more than three nymphs have been observed on a leaf. In captivity, however, they may be laid close together but never in circles. The eggs are dusted very lightly with a waxy powder but it does not make the surrounding area in any way conspicuous. Females are very active and take to flight at the slightest provocation.

The species is single brooded, oviposition in nature commences actively towards the end of May. The duration of the egg stage, during 1937, extended from 30 to 36 days during June and July. The duration of the 1st instar lasted from 15 to 27 days and of the 2nd instar from 14 to 20 days (Table V). The earliest pupa was noticed on 12.viii., but this was in no way a representative case because this brood was from eggs laid in the first week of May (the pupae collected from the fields were kept in a hot-house from which the adults emerged and laid eggs in captivity much before they were obtained in nature). In nature, however, only the 3rd instar nymphs were met with during that part of the year, and pupae from the respective food-plants were collected in early September.

Overwintering takes place in the pupal stage. The leaves with the pupae remain hanging on the trees or bushes for a long time or may fall to the ground, where the insect passes the winter. From pupae bred in the laboratory and those collected in the field, when kept indoors from October 1937 onwards, the adults commenced emerging from the first week of March, 1938.

Observations during April and May show that some of these pupae are parasitised and the extent of parasitism may be as high as 40%.

iii. *Cross inoculation.* Cross inoculations of the so-called species *A. carpini* and *A. rubicola* were tried and development noted. Adults were obtained in the laboratory from pupae collected separately from hornbeam and wild blackberry. They were then bred on their respective alternative food-plants. The general behaviour of all the stages in both cases was similar and the insects thrived well and developed quite normally on the alternative plants (Table V).

Alternative host-plants. The species is not confined to hornbeam and blackberry. Adults have been collected from raspberry, oak and hazel as well, but the examples may have been casual visitors. During September and October, 1937, however, numerous pupae of this species were collected on hazel [3] at Bricketwood. This provides considerable evidence to indicate that the species thrives quite well on this food-plant in nature. The adults from these pupae emerged in March, 1938, in the laboratory, approximately at the same time as those emerged from the pupae on hornbeam.

[3] Probably this coincidence was responsible for placing *A. carpini* and *A. avellanae* under the genus *Asterochiton* as proposed by Harrison.

TABLE V.

Life-cycle and cross inoculations of *A. carpini*, on alternative host-plants, 1937–1938.

Adults collected from	Life-cycle completed on	Date of introducing the adults	Earliest date of hatching of eggs	Earliest date of 1st moult	Earliest date of 2nd moult	Earliest date of emergence of adults	Shortest duration of life-cycle in days
		1937	1937	1937	1937	1938	
Rubus fruticosus	*Carpinus betulus* [1]	2.v.	7.vi.	28.vi.	12.vii.	6.iii.	308
Carpinus betulus	*Rubus fruticosus* [2]	23.v.	28.vi.	—	—	8.iii.	289
Carpinus betulus	*Rubus fruticosus*	30.v.	3.vii.	21.vii.	10.viii.	10.iii.	284
Carpinus betulus	*Carpinus betulus*	1.vi.	2.vii.	18.vii.	—	9.iii.	281
Rubus fruticosus	*Carpinus betulus*	2.vi.	3.vii.	21.vii.	9.viii.	6.iii.	277
Rubus fruticosus	*Carpinus betulus*	5.vi.	7.vii.	23.vii.	—	6.iii.	274
Carpinus betulus	*Carpinus betulus*	9.vi.[3]	10.vii.	26.vii.	10.viii.	6.iii.	270
Rubus fruticosus	*Rubus fruticosus*	11.vi.[1]	12.vii.	—	—	8.iii.	270
Rubus fruticosus	*Carpinus betulus*	11.vi.	10.vii.	26.vii.	9.viii.	3.iii.	265
Carpinus betulus	*Carpinus betulus*	11.vi.[1]	13.vii.	28.vii.	—	6.iii.	268
Rubus fruticosus	*Rubus fruticosus*	15.vi.[2]	—	—	—	8.iii.	266
Carpinus betulus	*Rubus fruticosus*	15.vi.[1]	16.vii.	—	—	8.iii.	266
Pupae on *Corylus avellana* [3]		—[3]	—	—	—	3.iii.	—

[1] Hornbeam.
[2] Blackberry.
[3] Numerous pupae of the *carpini* species were collected from hazel at Bricketwood on 5.x.1937. The adults from them emerged in March, 1938.
The pupae from different experiments given above were kept in the laboratory, hence the date of emergence is comparatively earlier than in nature.

Description of the stages of A. carpini [4] *Koch* (figs. 3, 4, 5).

Egg. Oblong, apical end narrower, pedunculate, chorion smooth: light yellow when fresh, subsequently turns to dark brown; average measurements 0·24 × 0·10 mm., stalk about 0·03 mm.

Nymph 1st instar. Elliptical; light yellow but turns to brownish later on; margins surrounded by a waxy fringe, average measurements 0·23 × 0·20 mm. Marginal spines 17 pairs; dorsal spines three pairs, minute—antennal, abdominal, and vasiformal. Ventral spines—vasiformal. Antennae developed, three segmented, the 3rd the longest and provided with two spines (fig. 3), average length 0·08 mm. Eyes divided; legs functional. Vasiform orifice 0·04 × 0·03 mm., inner lateral margins not thickened; operculum nearly semicircular with a latero-posterior notch at the caudal margin, average measurements 0·02 × 0·03 mm.; lingula relatively expanded towards the posterior half, a few prominent hairs laterally at the distal end; length 0·02 mm. and more than half exposed beyond the operculum (fig. 3).

Nymph 2nd instar. Oval, yellowish-green; margin crenulate with a narrow waxy fringe all round, average measurements 0·46 × 0·32 mm. Marginal spines three pairs, cephalic, and caudo-lateral, minute, anals prominent; dorsal spines three pairs, minute; ventrals 1–2 pairs; submarginals as 4 or 5 minute hooks, running posterior to the mycetoma. Eyes entire; legs degenerate; antennae atrophied, directed backwards (fig. 3) and, on an average, 0·02 mm. long. Vasiform orifice pyriform, average measurements 0·05 × 0·04 mm., inner lateral margins roughened by thickening; operculum almost semicircular, caudal margin hairy, average measurements 0·02 × 0·04 mm.; lingula long and thick, spatulate, armed distally with a pair of prominent hairs; average length 0·03 mm. and more than half exposed beyond the operculum (fig. 3).

Nymph 3rd instar. Shape as in previous instars, broadly flattened dorso-ventrally, margins dentate; yellow-green, almost concolorous with the leaf; average measurements 0·78 × 0·57 mm.; marginal waxy fringe very narrow, thoracic tracheal folds evident. Spines as in the preceding instar. Eyes entire or divided; legs degenerate; antennae atrophied, directed inwards and ending in a hook (fig. 3), length about 0·03 mm. Body of

[4] For generic position see p. 585.

the developing insect marked by an *oval*; abdominal segmentation obvious and marked by transverse partitions, each of which bears minute circular tuberosities towards its extremities. Vasiform orifice pyriform, with a furrow extending to the caudal margin; average measurements 0·08 × 0·06 mm., inner lateral margins and the floor of the orifice roughened by thickenings; operculum and lingula brownish in colour; operculum almost semicircular, average measurements 0·03 × 0·05 mm.; lingula as in the previous instar, average length 0·06 mm. (fig. 3).

Pupa. Elliptical, greenish-yellow when newly transformed, whitish-opaque later, broad, slightly convex dorsally; margin crenulate and fixed to the leaf; submarginal area wide

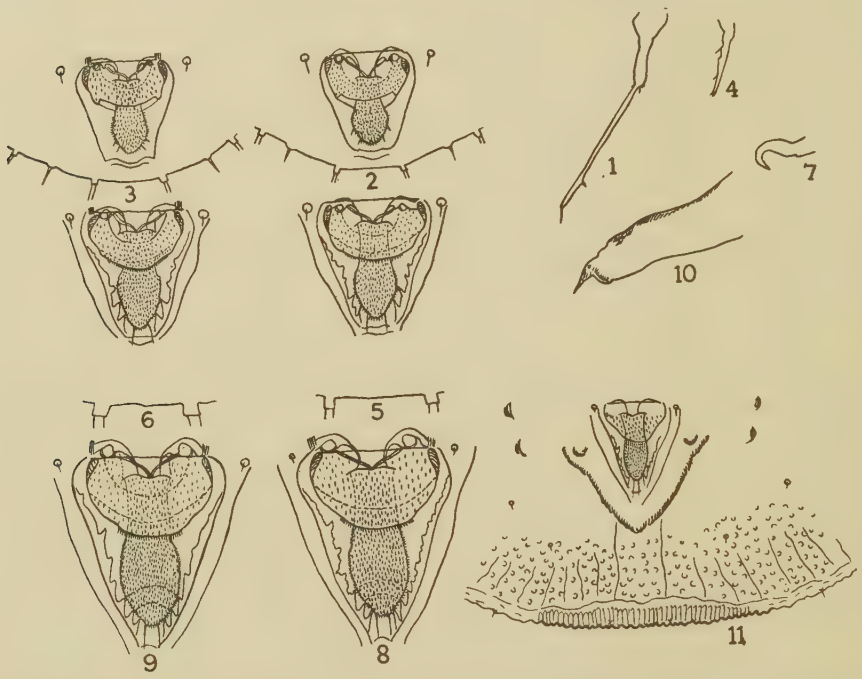

Fig. 3.—*A. carpini*, 1, antenna of 1st instar larva; 2, vasiform orifice of 1st instar larva from hornbeam; 3, vasiform orifice of 1st instar larva from blackberry; 4, antenna of 2nd instar larva; 5, vasiform orifice of 2nd instar larva from hornbeam; 6, vasiform orifice of 2nd instar larva from blackberry; 7, antenna of 3rd instar larva; 8, vasiform orifice of 3rd instar larva from hornbeam; 9, vasiform orifice of 3rd instar larva from blackberry; 10, antenna of pupa; 11, anal margin and vasiform orifice of pupa.

with concolorous transverse striations, average measurements 1·23 × 0·92 mm. Outline of the developing insect differentiated by an *oval* formed of whitish warts. Three tracheal folds—two thoracic and one anal—each ending at the margin of the pupa in a comb of teeth with a brittle, white frill of wax protruding beyond the margin. Marginal spines extremely minute, caudo-laterals prominent; dorsal spines two pairs, minute; ventrals 1 or 2 pairs and submarginals 2–4 pairs. Eyes entire, antennae directed backward and outward, and ending in a narrow process (fig. 3); about 0·07 mm. long; legs curved, degenerate. Vasiform orifice elongated, triangular, longer than broad; average measurements 0·10 × 0·07 mm., inner lateral margins and the floor of the orifice thickened; operculum and lingula brownish; operculum semicircular, average measurements 0·04 × 0·06 mm.; lingula stout and spatulate and armed distally with a pair of prominent hairs;

average length 0·07 mm. and rather more than half exposed beyond the operculum (figs. 3 & 4).

Adult. (Male.) Yellow or light orange in colour, body without any sculpture, about 1·1 mm. in length, wings white, marginal veins bright yellow; tip of rostrum brown. Eyes constricted, both the halves united by a bridge of a single facet (fig. 5). Antennae of seven segments—I sub-globose, II pyriform, beset with a few minute spines, III longest of all and beset with three well-developed sensoria distally, IV sub-cylindrical, the smallest, V almost clavate with one sensorium at the distal end, VI elongate, VII cylindrical, tapering distally and provided with a sensorium and ending in a spine; segments from III

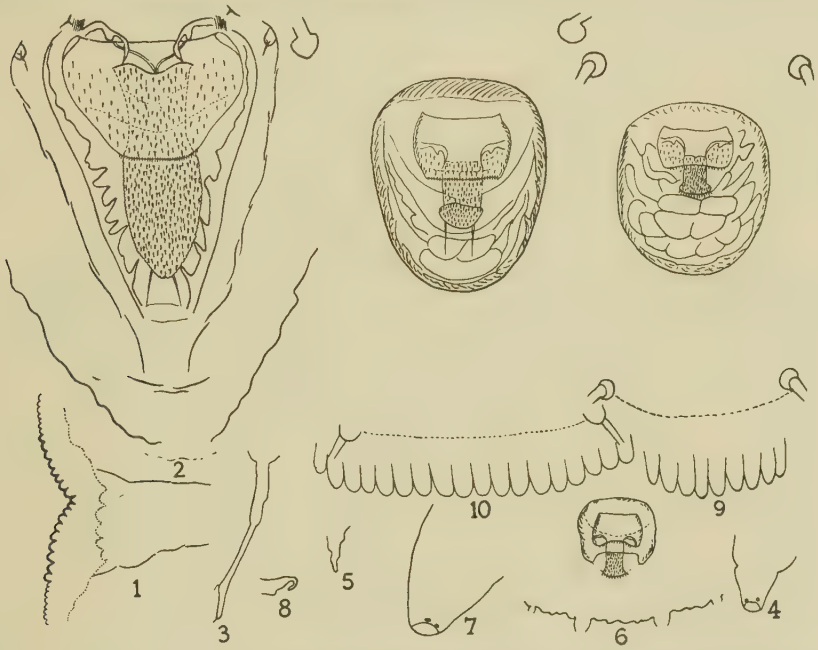

FIG. 4.—1–2, *A. carpini*, 1, thoracic tracheal fold of pupa; 2, vasiform orifice of pupa; 3–9, *S. phillyreae*, 3, antenna of 1st instar larva; 4, leg of 2nd instar larva; 5, antenna of 2nd instar larva; 6, vasiform orifice of 2nd instar larva; 7, leg of 3rd instar larva; 8, antenna of 3rd instar larva; 9, vasiform orifice of pupa; 10, *S. immaculata*, vasiform orifice of pupa.

to VII imbricate. Vasiform orifice broader than long; operculum rectangular; average measurements 0·03 × 0·05 mm.; caudal margin slightly arched and hairy; lingula short and thick, tip rounded and armed with minute hairs; length about 0·03 mm. (fig. 5); parameres medium in size, length about 0·14 mm., aedeagus long and almost straight, length 0·12 mm. (fig. 5).

Female. Concolorous with the male, may be slightly bigger. Antennae a little longer than in the male (see Table VI). Abdomen relatively broader at the base. Vasiform orifice as in the male. Genitalia as usual in the family; each dorsal valve provided with a pair of prominent hairs near the basal region of the inner valves (fig. 5). (For measurements of antennal segments see Table VI.)

Asterobemisia gen. n.

Prior to the classification of ALEYRODIDAE by Quaintance and Baker (1913–14) practically all the European species of this family were listed under the

genus *Aleyrodes*. Quaintance and Baker did not assign *A. carpini* to any genus but included *A. rubicola* under *Aleyrodes*. Marriner and Laing (1931) were satisfied with its original position under *Aleyrodes*, but Harrison (1920 and 1931), on the other hand, shifted *A. carpini* to *Asterochiton* but retained *A. rubicola* under *Aleyrodes*. Somehow the identity of these forms seems to have been overlooked, and this unfortunately resulted in a different systematic position even with regard to the genera.

The genus *Asterochiton* was founded by Maskell (1879) with his species *lecanioides* and was placed in the Coccidae. Quaintance and Baker (1914), however, regarded Maskell's type as an example of *vaporariorum*. Baker and

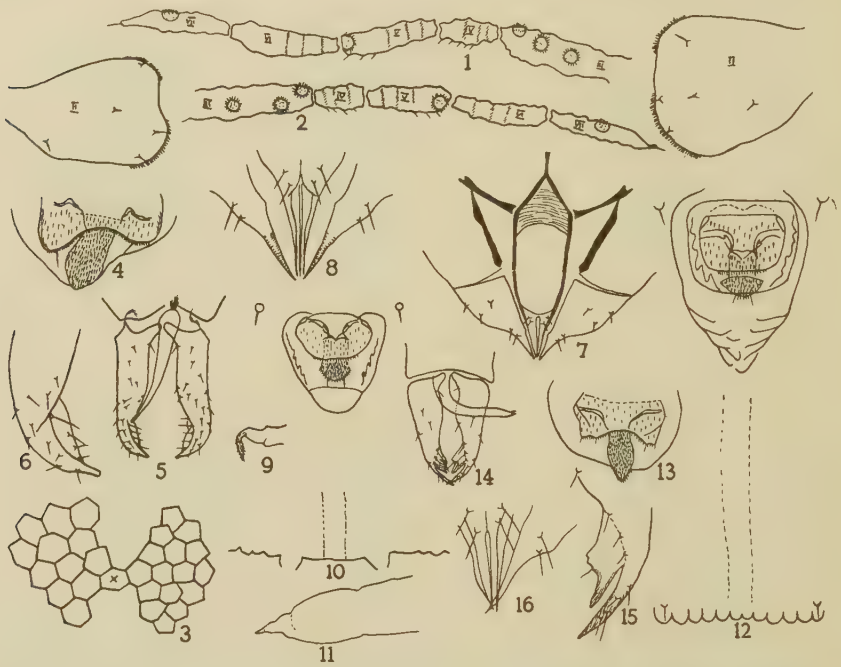

Fig. 5.—1–8, *A. carpini*, 1, antenna of female; 2, antenna of male; 3, eye of adult; 4, vasiform orifice of adult; 5, genitalia of male; 6, tip of a paramere; 7, genitalia of female; 8, ovipositor of female; 9–16, *P. quercus*, 9, antenna of 3rd instar larva; 10, vasiform orifice of 3rd instar larva; 11, antenna of pupa; 12, vasiform orifice of pupa; 13, vasiform orifice of adult female; 14, genitalia of male; 15, tip of a paramere; 16, ovipositor of female.

Moles (1921) maintained the genus *Asterochiton* but specified different characters. The new generic characters were summarised by Singh (1931). Comparing the characters given under *Asterochiton* with those given under *Dialeurodoides* by Quaintance and Baker (1914), it appears that the former has simply replaced the latter.

It may be pointed out that the structure of the pupa in *A. carpini* and the long triangular nature of the vasiform orifice, do not bring this species in any way near to the old genus *Asterochiton* or the one described later by Baker and Moles. Morphologically the structure of the vasiform orifice in *A. carpini* is almost similar to that described under *Bemisia*, but it differs in having no caudal furrow; the presence of the tracheal folds ending in a comb of teeth,

the oval formed by a series of warts concolorous with the body and the structure of the vasiform orifice, form a characteristic structural combination, which brings it between the above genera. The new genus *Asterobemisia*, therefore, is proposed, with *Aleyrodes carpini* Koch as the type species.

TABLE VI.

Measurements of antennae in the male and female of *Asterobemisia carpini*.

Sex	Average measurements of antennal segments							
	I	II	III	IV	V	VI	VII	Total length of the antenna
♂	0·03	0·06	0·13	0·02	0·03	0·03	0·04	0·34 mm.
♀	0·03	0·07	0·15	0·02	0·04	0·04	0·05	0·40 mm.

Aleyrodes proletella Linn. 1758 and *A. brassicae* Walker 1852.

The species under discussion was the first to attract the attention of naturalists. Réaumur (1736) described a species with two spots on the elytra and included it in the Lepidoptera. Linnaeus (1758) named the species *proletella* and mentioned *Brassica* and *Chelidonium* as its food-plants. Roemer (1789) briefly described the species *chelidonio* but Latreille (1796) diagnosed its hemipterous characters and described the species again. Burmeister (1835) published a slightly better account of the insect giving, however, only superficial characters which apply to the whole group; the diagram of the adult shows a forked vein in the wing. Westwood (1840) recorded *A. proletella* infesting cabbages, *Chelidonium* and oaks. Ruricola (1846) described *A. proletella* but doubtfully regarded the antennae as five segmented. His observations, " infesting cabbages, called also by Latreille *A. chelidonio* from its living upon the great Celandine (*Chelidonium majus*)," yield evidence that both forms were considered identical. Walker (1852) regarded *A. brassicae* as a variety of *A. proletella*. Koch (1857) described some of the superficial characters of the adult of *A. brassicae*. Frauenfeld (1867) reviewed the previous accounts of *A. brassicae* by Walker and Koch and considered it distinct from *A. proletella*. Signoret (1868), on the other hand, presented a much fuller account of the species, and described the colour of the adult *A. proletella* and added a detailed account of its immature stages. His description of *A. brassicae* was equally complete and some supposed differentiating characters in the 1st instar larvae were given. Douglas (1895) considered the two forms as distinct species, but his observations were based mostly on preserved material. He supported Signoret with respect to the differentiating characters in the 1st instar larvae without examining that stage. Tullgren (1907) was the first to state the identity of the forms on morphological characters. He was convinced that the differences pointed out by Signoret and Douglas were not genuine and that the forms were identical. Laing (1921), in a note on *A. proletella* (L.), stated " this species is not confined to the genus *Brassica*, it also is to be found on *Chelidonium majus*. It is generally stated that another species (*A. brassicae* Walker) is also found on cabbage, but I have not yet been able to satisfy myself as to whether this is really a distinct species." Marriner (1931), on the other hand, regarded each of these forms as distinct species. Deshpande (1933) gave a detailed account of *A. brassicae*, and maintained the individuality of the

respective species *A. proletella* and *A. brassicae*. On the contrary, Haupt (1935) considered both forms identical in their morphological characters, and Weber (1935) described the genitalia in *A. brassicae*.

Present investigations and the evidence in favour of the identity of A. proletella *and* A. brassicae.

1. *Structural.*

The basic differential characters as suggested by Signoret and supported by Douglas were to be found in the larvae of the 1st instar. Signoret remarked that the larvae of *A. proletella* were oval and showed all round a border of fairly long hairs, in all 34–36, the four longest being at the extremity of the abdomen. In *A. brassicae*, on the other hand, the larva was stated to be more elongated and less rounded, with hairs only on the abdominal segments and with only two long hairs towards the extremity.

During the present investigation, an examination of over 100 1st instar larvae of *A. brassicae* has shown that 16 or 17 pairs of marginal spines are present all round the larva, including the thoracic as well as the cephalic regions. Further, two of the posterior pairs, with a small spine between them on each side, are long and prominent (fig. 6). These observations are in agreement with those of Deshpande (1933), who described the 1st instar larva of *A. brassicae* and stated: "There is a rimlike narrow margin from which 16 pairs of small hairs arise, of which one anterior and two posterior pairs are prominent and long." Hence, it may be concluded that the difference noted by Signoret in the distribution of their marginal hairs and the prominence of a single posterior pair of bristles in *A. brassicae*, was most probably the result of restricted observations or defective technique.

To verify the significance of the suggested difference in the shape of these nymphs, measurements of 43 individuals of both forms, bred in the laboratory, were taken for comparison. Two factors were taken into consideration: namely, the length of the individuals and the relative ratio of their length to breadth.

Considerable variations have been noticed in the individuals of both the forms, but there appeared no indication that their average measurements were in any way different, or that individuals from two different food-plants belonged to different populations.

Besides, the comparative study of the various stages yielded conclusive evidence that the various stages of *A. brassicae* are inseparable morphologically from those of the allied form on *Chelidonium majus*, hitherto known as *A. proletella*. The forms are, therefore, considered identical and may be called *A. proletella* Linn., this being the earlier name.

2. *Biological.*

a. *Cross inoculations.* Adults bred from their respective food-plants were transferred to alternative plants, where the respective males and females from different plants mated and laid eggs. The immature stages flourished without affecting the life-cycle (Table VII). It was observed that the shortest duration of the life-cycle on both plants varied from 42 to 48 days during April and May, and from 33 to 36 days during June to September.

b. *Comparative oviposition.* To determine any preference in the food-plants by the adults, relative oviposition was studied under laboratory conditions simultaneously on cabbage and *Chelidonium majus*. Cabbage seedlings were grown in pots which contained small shoots of Celandine and a known

number of newly emerged adults of *A. proletella*—10 or 12 females with half the number of males, was introduced for oviposition under lamp glasses. Two such experiments, each with two repetitions and with an exposure of four days, gave the following results :—

Host-plant	Leaf area, sq. cm.	No. of eggs laid	Eggs per sq. cm.
1. Cabbage	94·6	93	0·98
Celandine . . .	235·6	40	0·17
2. Cabbage	94·3	85	0·90
Celandine . . .	201·1	31	0·15

Eggs were laid readily on both the host-plants but in spite of the relatively greater leaf area of Celandine, the insect showed some preference for cabbage.

c. *General remarks and food-plants.* The species is found all the year round and overwinters in the pupal as well as in the adult stage. The eggs are laid in rings, although occasionally a few scattered ones were also noticed, and are dusted over by white waxy powder. The maximum number of eggs laid by a single female, in captivity, from 22.vi. to 1.ix., was 219 in the 70 days. The same female also gave the maximum duration of life of an adult during summer.

The species, however, is not confined to its recorded food-plants. During May, in nature, adults have been observed laying eggs on wild *Sonchus* sp., on which the immature stages develop. Besides, the adults have also been noticed taking shelter on strawberry plants during winter. Although the species is not known to breed on strawberries in nature, nevertheless attempts made in captivity were successful. In one case the life-cycle could not be completed but in the second case (Table VII) the cycle was completed successfully.

TABLE VII.

Life-cycle and cross inoculations of *A. proletella* on alternative hosts.

Adults bred from	Life-cycle completed on	Date of introducing adults	Earliest date of the hatching of eggs	Earliest date of the emergence of adults	Shortest duration of life-cycle
		1937	1937	1937	
Brassica oleracea	*Chelidonium majus*	5.iv.	19.iv.	17.v.	42
Brassica oleracea	Strawberry (*Fragaria* sp.)	5.iv.	20.iv.	23.v.	48
Brassica oleracea	*Chelidonium majus*	8.iv.	23.iv.	26.v.	48
Brassica oleracea	*Brassica oleracea*	12.iv.	26.iv.	27.v.	45
Chelidonium majus	*Brassica oleracea*	21.vi.	—	25.vii.	34
Chelidonium majus	*Brassica oleracea*	*22.vi.	—	26.vii.	34
Chelidonium majus	*Brassica oleracea*	23.vi.	—	27.vii.	34
Brassica oleracea	*Chelidonium majus*	23.vi.	—	26.vii.	33
Brassica oleracea	*Chelidonium majus*	29.vi.	9.vii.	4.viii.	36
Chelidonium majus	*Brassica oleracea*	7.viii.	15.viii.	12.ix.	36

* Maximum number of 219 eggs was laid by a single female in 70 days.

Besides the genus *Brassica* and Celandine, this species was observed for the first time, on 27.ix.1937, breeding freely on Canterbury bells (*Campanula* sp.).

Description of the stages of A. proletella *Linn.* (fig. 6).

Deshpande (1933) incorporated the description of all the stages in his account of *A. brassicae*. It is not justifiable to repeat the descriptions in full, but it is desirable to supplement them with a view to pointing out differences or filling up gaps.

Nymph 1st instar. According to Deshpande the larva remains active for three days. This statement, however, does not agree with my observations. Forty-five newly hatched nymphs were examined for this purpose and many more connected with other observations, but in most of the cases they were fixed practically on the day after hatching. The prolonged activity noticed

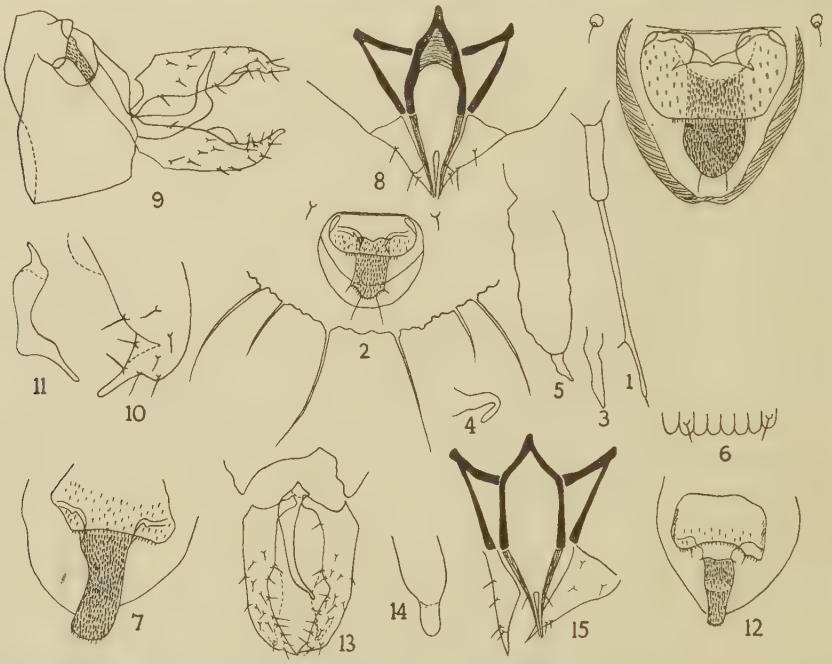

Fig. 6.—1–11, *A. proletella*, 1, antenna of 1st instar larva; 2, vasiform orifice of 1st instar larva; 3, antenna of 2nd instar larva; 4, antenna of 3rd instar larva; 5, antenna of pupa; 6, vasiform orifice of pupa; 7, vasiform orifice of adult; 8, genitalia of female; 9, last abdominal segment and genitalia of male; 10, tip of a paramere; 11, aedeagus of male; 12–15, *S. immaculata*, 12, vasiform orifice of adult; 13, genitalia of male; 14, tip of aedeagus; 15, genitalia of female.

by Deshpande might have been an extraordinary feature restricted to certain food conditions. Eyes are quite distinct and may be entire or divided. The antennae (fig. 6) are long and measure about 0·11 mm. The dorsum is not devoid of spines, but possesses three pairs of minute spines—antennal, thoracic and vasiformal. Besides, two or occasionally three pairs of ventral spines are also visible. Vasiform orifice sub-circular, slightly broader than long (fig. 6), average measurements 0·03 × 0·04 mm.; operculum sub-rectangular, faintly hairy on its caudal margin, average measurements 0·01 × 0·03 mm.; lingula long, cylindrical, setose all over, distal end with a pair of long hairs and a relatively shorter one on either side, average length about 0·02 mm. and about $\frac{3}{4}$ exposed beyond the operculum.

Nymph 2nd instar. Marginal spines 2–3 pairs, dorsal spines also 2–3 pairs. Deshpande missed these but mentioned a pair cephalad to vasiform orifice late in the pupa, which gives the impression that probably they appear in that stage for the first time. On the contrary, that particular pair is present in all nymphal stages. Eyes small, reddish and generally divided. The antennae, not mentioned by Deshpande, are present but reduced, directed backwards (fig. 6), average length 0·02 mm. Vasiform orifice almost subcordate, average measurements 0·04 × 0·05 mm.; operculum sub-rectangular, 0·02 × 0·04 mm.; lingula cylindrical, a little spatulate and with a pair of long prominent hairs at the tip, average length 0·02 mm. and about $\frac{2}{3}$ exposed beyond the operculum.

Nymph 3rd instar. Margin dentate, spines as in the previous instar. Antennae atrophied, directed inward and hooked, average length 0·03 mm. (fig. 6). Eyes entire. Deshpande's remark " eyes appear as small red spots " gives an impression that probably they appear in this stage for the first time, but they are quite conspicuous in all the instars. Vasiform orifice subcordate, inner lateral margins thickened, average measurements 0·05 × 0·06 mm.; operculum sub-rectangular, measurements 0·03 × 0·05 mm.; lingula thick and cylindrical, average length 0·03 mm., about $\frac{2}{3}$ exposed beyond the operculum.

Pupa. Marginal spines 1–3 pairs, the anals always present but invariably minute. This is not in agreement with Deshpande's observations, who mentions them as a pair of long spines. The antennae directed backwards and outwards and ending in a small process (fig. 6). Vasiform orifice subcordate with the inner lateral and caudal margins uniformly thickened, measurements 0·07 × 0·07 mm. (fig. 6); operculum about 0·03 × 0·05 mm.; lingula as in the previous instar, average length 0·04 mm.

Adults. Deshpande's description of the adults is far more detailed than that of the immature stages. The male and female genitalia, however, require some comment because his figures appear too diagrammatic. In the female, the basal sclerites are shown extending to the margin of the body, evidently much longer than they are in fact. As a rule, these flat basal portions never extend beyond the junctions where they meet the lateral ones. Also, the dorsal valves are shown running in continuation with the inner chitinous press (terms after Weber, 1935), indicating, thereby, no structural difference. In well-prepared specimens these valves are clearly marked out and are distinct from the press mentioned above (fig. 6).

The diagrams and interpretation of the male genitalia do not agree with my observations. Deshpande remarked that the parameres (claspers) are " deeply forked " but this is not found to be the case (fig. 6). The aedeagus, which is represented as almost straight, is found to be angularly curved, more or less boot-shaped in outline (fig. 6).

This feature is quite characteristic of the species and gives strong evidence in support of the identity of the two forms *A. brassicae* and *A. proletella.* Tullgren (1907) also explained it as " Der penis stark winkelig aufgebogen."

Aleyrodes quercus Signoret 1868 and *A. avellanae* Signoret 1868.

Both these species were originally described by Signoret (1868), *quercus* on p. 384 and *avellanae* on p. 385. Following is a brief translation of the description of the adult and the larva of *A. quercus* :—

" *Adult.* Yellow-brown on the body and pale yellow on the abdomen; spotted with blackish. Head globular; vertex black, front brownish-black, cheeks yellow. Antennae greyish-yellow, eyes strongly divided. The pro-, meso- and metathorax blackish, sutures

pale. Black spots on median chest. Abdomen strongly pedunculate, yellow and black at the tip. Legs blackish, tibiae lighter, generally yellowish. Claws of the sexual organs of male blackish and developed. Elytra with a large blackish spot at the extremity of the median nerve. Sometimes, as in other species, pale individuals without spots are met with.

" *Larva.* Very remarkable. All that is outside the actual body of the insect is regularly punctate, the punctations radiating from the body and get larger towards the circumference. Each abdominal segment shows on each side a tubercle in the youngest larvae . . ."

The same author gave an account of the larva under *A. avellanae* and a copy of a translation by Douglas is quoted here :—

" But the larva is easy to distinguish, since it has, like that from the oak, some cavities in the form of excoriations on the median line of the abdomen; the sides, or expansion around the body, are much broader, more transparent, more foliculated, very wrinkled, and at the point of distinction of this expansion of the body properly so-called, there are also the same kind of excoriations on each segment, eight on each side and some of them also near the cephalic portion. On each side of the median line, on the first and second abdominal segment, is a blackish spot; the extremity of the abdomen or anus elongate and brownish . . ."

Douglas (1894) described, very briefly, the adults of *A. avellanae* as entirely " gamboge-yellow; eyes black, not divided; wings white, transparent, without a dark spot, marginal nerve yellow." Quaintance and Baker (1914) assigned *A. quercus* to the genus *Aleyrodes* but did not propose any generic position for *A. avellanae.* Since then both species have been totally ignored except for a few references in literature. Harrison (1920 and 1931) considered the generic position of both forms and placed *A. avellanae* in the genus *Asterochiton,* but retained *A. quercus* under *Aleyrodes.* Deshpande (1933) mentioned briefly the eye and the reproductive system of *A. quercus.* Haupt (1935) stated a few characters of the pupa and the adult of *A. quercus*; but his account appears to be a translation of Signoret's description.

It may be concluded that Signoret proposed the differentiating characters in the larvae of *A. avellanae,* which were stated to have a broader margin than in *A. quercus* and a pair of blackish spots on the 1st and 2nd abdominal segments. Douglas, on the other hand, considered the food-plant as a diagnostic feature. He described the adult of *A. avellanae* without any black markings.

Present Investigation.

The species under discussion needs comments in respect to the description of the stages as well as its systematic position.

1. Adult (*A. quercus* type). In 1932, Dr. C. B. Williams received a few adults collected from oak plants at Wye, Kent, and in 1935 discovered the species in small numbers at Batford, Herts. This material was kindly given to me for examination. The adults were entirely yellow and without any brown markings on the body. The parameres in the male were relatively small in size and concolorous with the abdomen. On 1.vi.1937 I collected one male specimen from oaks at Batford, Herts, which possessed similar characters to those described above. The genitalia was identical to that observed in the specimens sent from Wye during 1932. During October, 1937, some pupae were collected from oak and hazel in Bricketwood, Herts, and kept in a hot-house. A few adults emerged from these pupae in March and April, 1938. Hence the convincing information regarding colour and structure was obtained from the adults which emerged in the laboratory. These adults

were uniformly yellow and without any grey markings on the body. The genitalia of the males was exactly similar to that found in the previous examples.

It is evident from these facts that Signoret's adults of *A. quercus* were not specimens of this species. As already suggested, it appears probable that the adults of *A. lonicerae* were mistaken for this species when collected from oak, where they generally take shelter during autumn.

The adults that emerged from the pupae on hazel (*A. avellanae* type) almost simultaneously with those from oak, were also pure yellow and resembled in all characters those from oak. It is, therefore, possible that the specimens described by Douglas as *A. avellanae* might be examples of this species.

2. *Larva.* Signoret's proposed differential characters are superficial and of no specific value. On the contrary, the pupae examined from the respective food-plants have now shown identical characters.

Therefore, the identity of both so-called species is established on the characters of the pupae as well as of the adults in general and those of the vasiform orifice and the genitalia in particular. The pupae from hazel, however, often show varied forms because of the presence of the rough surface of the leaves. The descriptions given at the end apply to both forms.

Biology and Food-Plants.

The only adult from the field was collected on oak at Batford, on 1.vi.1937. Some more adults of white-flies were collected from oaks and hazels, both at Bricketwood and Batford, but on examination they were found to be *A. carpini.* During August 1937, a few nymphs in 3rd instar were collected from oaks. At the same time, on 5.viii., one nymph of this species in the 3rd instar was found on hornbeam at Batford. Again on 20.ix. one more nymph in the 3rd instar was collected from hornbeam at Bricketwood. Later, on 11.xi. three pupae of this species were collected from hornbeam from the same locality. It appears evident from these observations that this species breeds in small numbers on hornbeam as well. From the pupae collected on oak and hazel during October and November, 1937, the adults emerged in March and April when kept in a hot-house. This species, therefore, appears to be single-brooded, and overwintering takes place in the pupal stage.

Description of the stages of Pealius quercus [4] (*Signoret*) (*fig.* 5).

Since all stages were not available, only the three last stages are described with a view to pointing out some of the important features.

Nymph 3rd instar. Greenish-yellow, broadly oval, flat, almost transparent, margin dentate, abdominal segmentation and thoracic tracheal folds faintly visible, measurements 0·64 × 0·46 mm. Marginal spines three pairs—cephalic and caudo-lateral, sub-equal and anal developed; submarginal spines minute, about 4 or 5 pairs abdominal and 2 or 3 pairs thoracic; dorsal spines three pairs—antennal, thoracic and vasiformal; also 4 or 5 extremely minute and practically imperceptible spines on either side of the median line; ventral spines minute. Eyes entire; legs degenerate; antennae atrophied, directed inwards, hooked at the tip, about 0·02 mm. long. Vasiform orifice relatively small, quadrate, caudal margin almost straight, forming the anterior boundary of a semicircular space posterior to it, measurements about 0·03 × 0·04 mm.; operculum almost transversely oval, caudal margin hairy, measurements about 0·02 × 0·03 mm.; lingula small and thick, knobbed distally, hairy all over and with two relatively long hairs at the tip, length about 0·02 mm. and about half exposed beyond the operculum.

[4] For note on genus see p. 600.

Pupa. Broadly oval, yellow when newly moulted, whitish opaque later on, slightly raised from the leaf surface, enclosed within a wall of wax and a thin layer of wax at the dorsum. Margin raised in a very low ridge all round; submarginal area broad and with punctations which run outward in regular rows; abdominal segmentations distinct, a series of 4 or 5 concolorous warts on either side of the median line; abdominal region separated from the thoracic by a yellowish semicircular ridge; thoracic tracheal folds visible but not prominent on the margin; average measurements 0·88 × 0·67 mm. Marginal spines, two pairs, anal and caudo-lateral minute; dorsal spines one or two pairs, almost imperceptible; ventrals absent or imperceptible. Legs and antennae as usual, the latter with a small terminal process, about 0·06 mm. long. Vasiform orifice in a depression, the surrounding area forming a pyriform outline, pit ribbed transversely towards the caudal half; orifice proper sub-rectangular, inner lateral margins slightly thickened, average measurements about 0·04 × 0·04 mm.; operculum slightly brownish, 0·02 × 0·03 mm., caudal margin hairy; lingula small, knobbed and spinous, the knobbed end exposed beyond the operculum, average length 0·02 mm.

Adult. (*Male.*) Entirely yellow, genitalia concolorous with the body, tip of rostrum brown; wings pure white, spotless, thin and almost transparent, venation—only the radial sector and a faint cubitus, marginal vein slightly yellowish. Eyes dark brown, constricted in the middle; legs lighter in colour. Antennae relatively small, segments I–III as usual, the 3rd the longest and provided distally with sensoria, IV the smallest, V cylindrical, longest of the distal four segments, provided with a sensorium, VI and VII almost equal, the last segment terminating in a spine. Abdomen tapering posteriorly, 1st abdominal segment transverse, narrow anterio-posteriorly, wax plates not marked by coloured margins. Vasiform orifice broader posteriorly, operculum almost sub-rectangular, about 0·02 × 0·03 mm.; caudal margin arched and hairy with a pair of relatively long hairs on either side; lingula small, relatively broader in the middle. Parameres small, slightly brownish at the tip, and deeply forked, about 0·10 mm. long; aedeagus relatively long, measuring about 0·09 mm.

Female. Concolorous with the male, which it resembles in general characters. Genitalia as usual, dorsal valves with a pair of long prominent hairs near the basal region of the inner valves.

Systematic Position.

The species under discussion are regarded as morphologically identical, and, in the absence of the thoracic tracheal folds ending in a comb of teeth in the pupa, as well as owing to the vasiform orifice being situated in a depression which is transversely ribbed, this species does not fall under the genus *Asterochiton* as proposed by Harrison. On the contrary, these characters ensure a better position for it in the genus *Pealius*, to which it is now assigned. I therefore propose that the species be regarded as *Pealius quercus* (Sign.).

Siphoninus phillyreae (Haliday 1835) and *S. immaculata* (Heeger 1855) (figs. 4, 6).

Haliday (1835) described the species *Aleyrodes phillyreae* and noted some superficial characters of the adult insect. Walker (1852) contributed an almost similar account of the species and briefly mentioned its pupal stage. Frauenfeld (1867) referred to the species but added no information about its immature stages. Signoret (1868) presented a vivid account of the various stages of *A. phillyreae* and regarded the species as distinct from *A. immaculata* which was originally described by Heeger (1855) from *Hedera helix*. He attached considerable significance to the relative number and size of the wax tubes on the pupae and regarded them as of specific value. Douglas (1884), when discussing the species *immaculata*, considered his specimens identical with those of

Heeger, but, in the absence of any specified characters, he was doubtful as to their identity and considered that his specimens might as well be the same as *A. phillyreae* of Signoret. Quaintance and Baker (1914) included both species under the genus *Asterochiton*. Silvestri (1914), however, erected a new genus *Siphoninus* for the species *finitimus* and assigned *A. phillyreae* to it. Some generic characters of the adult, such as the absence of paronychium and the structure of the vasiform orifice both in the adult and the pupa, were discussed. The position of the corresponding species *immaculata* was still undefined. Since then both species have been occasionally referred to by various workers.

Present Investigations.

To test the reliability of the differentiating characters in *S. phillyreae* and *S. immaculata* [5] proposed by Signoret, observations were made on the relative number and measurements of wax tubes on the pupae of both the species. These results are summarised in Table VIII. The total number of tubes varies from 62 to 74 in *S. phillyreae* and from 61 to 71 in *S. immaculata*. Their lengths also vary from 0·07 to 0·12 mm. and from 0·07 to 0·11 mm., with an average of about 0·10 mm. and 0·10 mm. respectively. As there is considerable overlapping in both the ranges, it is evident that neither of the features can be used with certainty to separate the two forms.

On the other hand, the following differences have been noticed during the present investigations :—

Pupa.

1. *Dorsum.* The shape and colour of the pupae are almost identical, but the pupa of *S. phillyreae* possesses tufts of white waxy material on the dorsum which are not met with in *S. immaculata*.

2. *Wax tubes.* The number and size of these tubes shows no appreciable difference in the two species. The unpaired tube on the 2nd abdominal segment is present in both forms, although Heeger did not show this in his diagram of *A. immaculata*. Nevertheless, their distribution is slightly different—the submarginal series in *S. immaculata* shows, in most cases, more tubes than in *S. phillyreae*; in the median series, on the other hand, the number is invariably higher in *S. phillyreae* (Table VIII).

3. *Vasiform orifice.* The most significant and reliable differences have been noticed in the structure of the vasiform orifice. In *S. phillyreae* (fig. 4) both the operculum and the lingula are smaller in size and the latter does not extend beyond the middle of the orifice. In *S. immaculata*, on the other hand, these structures are relatively bigger and the lingula, which has a conspicuous knob at the caudal extremity, extends considerably beyond the middle of the orifice (fig. 4).

Adult.

In *S. immaculata*, the entire body is uniformly yellow without any grey markings. In *S. phillyreae*, however, the grey bands on the abdomen and the mixture of grey and yellow on the entire body distinguish it readily from the other species.

Nevertheless, in case of any doubt, the vasiform orifice and the genitalia afford contrasting features.

[5] *A. immaculata* Heeger is assigned to the genus *Siphoninus* Silv. by me.

TABLE VIII.

Number and measurements of the wax tubes on the pupae of *S. phillyreae* and *S. immaculata*.

S. phillyreae								*S. immaculata*							
No. of the wax tubes on the pupa							Length of the tubes in mm.	No. of the wax tubes on the pupa							Length of the tubes in mm.
Sub-marginal		Median		Inner				Sub-marginal		Median		Inner			
Right	Left	Anterior	Posterior	Thoracic	Abdominal	Total		Right	Left	Anterior	Posterior	Thoracic	Abdominal	Total	
15	14	8– 7	6–7	2–2	5–1–4	71	0·10 0·09 0·10	19	17	6–6	5–5	2–2	4–1–4	71	0·10 0·11 0·10
11	11	6– 7	7–7	2–2	4–1–4	62	0·10 0·11	18	17	5–5	5–5	2–2	3–1–4	67	0·11 0·10
15	14	6– 6	7–8	2–2	4–1–4	69	0·11 0·10	17	17	5–5	5–4	2–2	4–1–2	64	0·10 0·10
13	14	8– 7	6–7	2–3	4–1–4	69	0·12 0·08	20	18	5–6	5–4	2–2	2–1–3	68	0·10 0·10
17	13	6– 6	7–7	3–3	4–1–4	71	0·07 0·08	15	16	5–6	4–5	2–2	3–1–2	61	0·11 0·11
14	15	7– 7	7–7	2–4*	4–3–5	74	0·08 0·09	16	17	5–5	5–5	2–2	4–1–3	65	0·11 0·10
14	12	6– 6	6–5	2–2	4–1–4	62	0·08 0·09	17	14	5–5	4–3	2–2	4–1–3	60	0·11 0·10
13	12	8– 7	7–7	3–3	4–1–4	69	0·09 0·11	16	18	6–5	4–4	2–2	3–1–4	65	0·11 0·10
14	15	8–10	6–6	2–2	4–3–3	73	0·11 0·12	15	14	5–5	5–4	2–2	4–1–4	61	0·09 0·09
13	14	8– 8	7–7	2–3	5–1–4	72	0·11 0·11	18	16	5–6	5–5	2–2	4–1–3	67	0·09 0·07
14	14	8– 7	6–7	2–3	4–1–4	70	0·11 0·11	16	17	5–5	5–5	2–2	4–1–4	66	0·07 0·07
13	13	7– 6	6–6	2–2	4–1–4	64	0·11 0·10	18	18	5–5	5–4	2–2	4–1–4	68	0·08 0·10
15	13	8– 7	6–5	2–2	4–1–5	68	0·10 0·11	17	16	5–6	5–4	2–2	4–1–3	65	0·11 0·11
14	15	6– 7	6–6	2–2	4–1–4	67	0·11	18	18	5–6	5–5	2–2	4–1–4	70	0·11
						Average	0·10							Average	0·10

* In this special case there were 1 cephalic, 1 mesothoracic and 2 metathoracic tubes.

i. *Vasiform orifice.*

In *S. phillyreae*, the lingula is broader at the base, and tapers distally, ending in a narrow tip (fig. 2) and may even be slightly bent. In *S. immaculata*, on the other hand, it is almost uniformly broad and appears as a two-segmented structure (fig. 6).

ii. *Genitalia.*

Male. The general shape and size of the parameres corresponds in both species. In *S. phillyreae*, however, there is a prominent tooth given out from the ventral surface of the paramere, just posterior to its inner membranous frill. It is differentiated from the claw by a triangular membranous tissue (fig. 2). In *S. immaculata* this tooth is not developed but replaced by an inconspicuous ridge on the ventral surface of the paramere (fig. 6).

Moreover, the aedeagus in *S. phillyreae* ends narrowly and its opening is armed by a pair of minute hooks (fig. 2). These are wanting in *S. immaculata*, but instead, the tip of the aedeagus is provided with a papilla-like outgrowth (fig. 6).

Female. The female genitalia shows but little differentiation except for the presence of a single bristle on either side near the base of the inner valves in *S. immaculata* (fig. 6) against a pair in *S. phillyreae* (fig. 2).

Biology. *S. phillyreae* was collected from *Phillyrea* plants at the John Innes Institution, Merton, Surrey, from which locality Dr. C. B. Williams has also recorded it in 1915. *S. immaculata* was collected from Ivy (*Hedera helix*) at Batford, Herts, in January, 1937.

In both these species, eggs are laid in clusters but not usually in circles, and are profusely dusted with a white waxy powder. The adults of *S. immaculata* are particularly sluggish and are not easily disturbed.

The eggs of *S. phillyreae* laid in the laboratory in the middle of August, 1937, hatched in about 16 days and the overwintering was in the nymphal stages. The emergence of the adults commenced from 16th May 1938. During 1937, however, some material was obtained from the John Innes Institution and Camberley. In both these cases the adults emerged during August and September and laid eggs in the laboratory.

S. immaculata is single-brooded. Nymphs collected in the field in January, 1937, were in most cases of the first instar. They were kept in a hot-house and adults emerged in April. Eggs were laid on ivy [6] in captivity and when kept in the same hot-house, they hatched after 35–39 days. The plants with the nymphs on them were removed to the insectary in June, 1937, but the life-cycle was not completed till May of the next year.

Description of the various stages of Siphoninus phillyreae (*Haliday*) (figs. 2, 4).

Since neither of these two species had been properly described, it was considered advisable to describe *S. phillyreae* and note the specific differences for the other species.

Egg. Oblong, pedunculate, yellow when freshly laid, changes to brown subsequently; measurements about 0·26 × 0·09 mm., stalk about 0·03 mm.

Nymph 1st instar. Elliptical, may be slightly elongated, a little convex dorsally; brownish,[7] more so in the middle; dusted profusely with the white waxy powder; fringe of white waxy plates all round; average measurements 0·30 × 0·17 mm. Margin with minute projections which indicate the bases of the marginal spines, of which there are sixteen pairs; submarginal area transversely striated. Dorsal spines minute, three pairs —antennal, abdominal and vasiformal; ventrals—rostral and vasiformal. Eyes generally entire; legs functional, three segmented. Antennae long and slender; apparently four segmented, average measurements 0·07 mm. Vasiform orifice close to the caudal margin, subcordate, average measurements 0·02 × 0·02 mm.; operculum sub-rectangular, measuring approximately 0·01 × 0·01 mm.; lingula short, setose, about 0·01 mm., mostly exposed.

Nymph 2nd instar. Oval; colour, shape and the fringe as in the previous instar, average measurements 0·41 × 0·25 mm. Margins slightly dentate; marginal spines four pairs—one cephalic and three caudals, the anals being the longest; a submarginal series of about eleven or twelve pairs of extremely minute spines; dorsal spines as in the previous instar; a single pair of ventral spines vasiformal in position. Six pairs of dorsal wax tubes—1 cephalic, 1 optic, 2 thoracic and 2 abdominal, running parallel to the margin. Eyes relatively small, legs degenerate, antennae atrophied about 0·02 mm. long, directed backward. Vasiform orifice sub-circular, posterior margin transversely notched, inner lateral margins slightly thickened, average measurements 0·03 × 0·03 mm.; operculum sub-rectangular, about 0·01 × 0·02 mm., caudal margin hairy; lingula cylindrical, spatulate towards the tip, about 0·01 mm. long and more than half exposed beyond the operculum.

Nymphal 3rd instar. The shape, colour and the marginal and submarginal spines as

[6] Two attempts were made to transfer adults of *S. immaculata* to *Phillyrea*, but in both cases the females died without laying eggs.

[7] Soon after hatching and moultings the colour of the nymph is yellow.

in the previous instar, waxy fringe narrower, average measurements 0·59 × 0·41 mm., dorsal spines comparatively better developed. Legs [8] degenerate, antennae [8] directed inward, hooked at the tip, length about 0·03 mm.; eyes small, entire. Dorsal wax tubes roughly in three series: (1) submarginal, 9 or 10 pairs—2 or 3 cephalic, 3 thoracic and 4 abdominal; (2) median, about 4 pairs—2 or 3 abdominal and 1 or 2 thoracic; (3) inner—2 thoracic and 1 abdominal. Vasiform orifice sub-circular, caudal half showing foam-like chambers; operculum 0·01 × 0·02 mm.; lingula about 0·02 mm., about $\frac{2}{3}$ exposed.

Pupa. Elliptical, raised within the closely surrounding ring of wax. Dorsum with tufts of white waxy material. Colour hazel brown outside, dark brown in the middle. Average measurements 1·02 × 0·74 mm. Margin lightly crenulate, caudal fold prominent with a row of teeth at the margin. Marginal spines absent; submarginals 14 or 15 pairs; dorsal spines three pairs, ventral spines wanting or a minute pair vasiformal in position. Dorsal tubes practically in three series but considerably increased in numbers—submarginal 11–15 pairs, often showing asymmetry in number on either side; median a little irregular in arrangements, 12–15 pairs; inner generally with 2 or 3 pairs of thoracic, 4 abdominals often showing asymmetry in their numbers and a single additional tube in the 2nd abdominal segment and occasionally 1 or 2 more on the posterior segments. The total number of these tubes ranges between 62 and 74. Legs and antennae as usual in the instar, the latter with a fine terminal process and measuring, on an average, 0·07 mm. Vasiform orifice sub-circular, slightly thickened at the margins, caudal half showing foam-like chambers, average measurements 0·06 × 0·05 mm.; operculum transversely rectangular, average measurements 0·01 × 0·03 mm.; lingula short and narrow, knobbed at the tip, about 0·02 mm. long and $\frac{2}{3}$ exposed beyond the operculum.

Adult. (*Male*) yellow, head and thorax uniformly yellow, metathorax often with a faint greyish mark. Eyes constricted, antennae seven segmented, greyish distally from the middle of the 3rd segment, segment III the longest, often showing variations in measurements, IV the smallest, V longer than IV, VI or VII. Tip of rostrum dark brown. Legs greyish distally, paronychium absent. Wings white, spotless, smoky towards the blade, outer marginal vein shining yellow, median vein darker distally. Abdomen yellow, dark bands on the 2nd abdominal segment prominent; margins of the wax plates dark; dorsally a few transverse bands of brown. The genitalia and the last abdominal segment grey. Vasiform orifice almost circular; operculum sub-rectangular; lingula long, narrowing distally (fig. 2), may be slightly bent, average length 0·03 mm., parameres well developed, each with a prominent tooth towards the distal end (fig. 2), average length 0·15 mm.; aedeagus with a pair of chitinous hooks at the tip, length 0·11 mm. (fig. 2).

(*Female*) concolorous with the male, but abdomen generally lighter in colour and with fewer cross bands; genitalia acute (fig. 2).

Dialeurodes chittendeni Laing 1928 (fig. 7).

The species was first recorded from Rhododendron by Hoare (1928), who doubtfully regarded it as belonging to *Pealius*. Laing (1928) named the species and described the characters of the pupa-case and adults. The generic position was assigned provisionally to *Dialeurodes* which is still maintained. Fox-Wilson (1929 and 1935) gave a brief account of this species as a pest of rhododendrons and mentioned briefly the immature and the adult stages with some remarks on the life-history. Latta (1937) published a brief note on this species as a pest of rhododendrons in the United States.

[8] Silvestri (1914) did not describe the nymphs of *S. finitimus* regarded as the genotype. Lately, however, Priesner and Hosney (1932) described the immature stages of an allied form *S. granati*. They have stated that the antennae and legs are wanting in the 2nd and 3rd instars. This does not agree with the present observations. These organs have been noticed in all species studied so far and are also present in *S. phillyreae*, as stated above.

The various stages of this pest are described in detail because a fuller account was needed.

Egg. Elongated, concave on one side, surface reticulate, peduncle long; inserted a little, shifted from the basal end; average measurements 0·24 × 0·11 mm., stalk 0·06 mm.; whitish when fresh, turns to brownish subsequently. The eggs are laid singly without any waxy powder dusted at the spot.

Nymph 1*st instar.* Greenish-yellow, concolorous with the leaf surface, elliptical, devoid of the waxy fringe, measures about 0·34 × 0·20 mm. Marginal spines 18 pairs—3 cephalic, 7 thoracic, 6 abdominal and 2 caudal; fifteen of these on either side arise from minute papillae the bases of which appear just submarginal in position; two pairs of

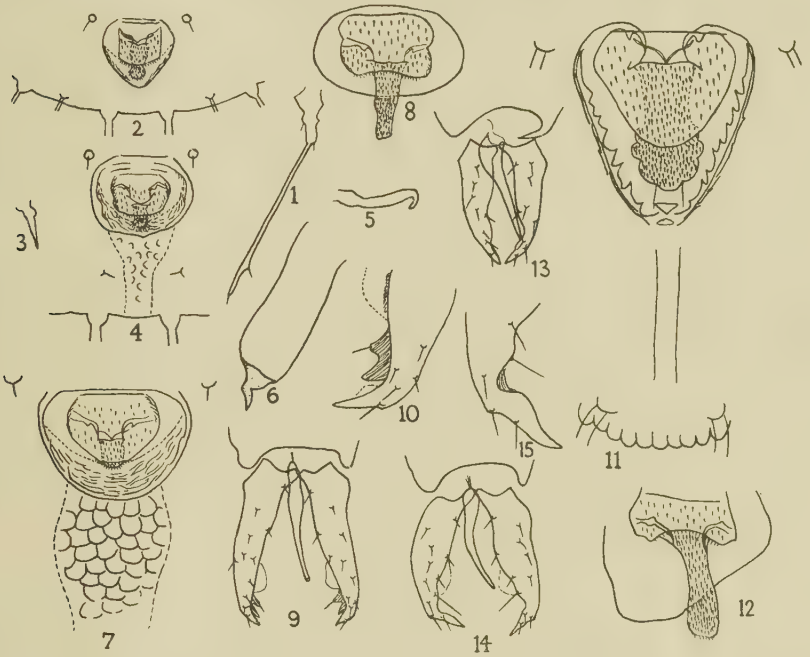

FIG. 7.—1–10, *D. chittendeni*, 1, antenna of 1st instar larva; 2, vasiform orifice of 1st instar larva; 3, antenna of 2nd instar larva; 4, vasiform orifice of 2nd instar larva; 5, antenna of 3rd instar larva; 6, antenna of pupa; 7, vasiform orifice of pupa; 8, vasiform orifice of adult; 9, genitalia of male; 10, tip of a paramere; 11–13, *T. vaporariorum*, 11, vasiform orifice of pupa; 12, vasiform orifice of adult; 13, genitalia of male; 14–15, *T. sonchi*, 14, genitalia of male; 15, tip of a paramere.

minute dorsal spines—antennal and vasiformal; two pairs of minute ventral spines—rostral and vasiformal. Eyes entire; antennae about 0·09 mm., distal segment ending in a spine; legs functional. Vasiform orifice cordate, measurements 0·02 × 0·03 mm.; inner lateral margins slightly thickened, operculum almost sub-squarish, about 0·01 × 0·02 mm.; caudal margin hairy, lingula small, 0·01 mm., knobbed distally.

Nymph 2*nd instar.* Greenish-yellow, almost transparent, elliptical but more rounded, without a waxy fringe, entire surface minutely papillate, measures about 0·45 × 0·31 mm. Marginal spines three pairs—cephalic, caudo-lateral, and anal; 12 or 13 pairs of extremely minute submarginal spines; three pairs of minute dorsal spines and two of ventral. Eyes entire; legs degenerate; antennae atrophied, directed backwards, about 0·02 mm. long. Vasiform orifice a little transversely elliptical, inner lateral margins slightly thickened,

measurements about 0·03 × 0·04 mm.; operculum almost similar, 0·02 × 0·02 mm.; lingula small, cylindrical, a little knobbed and exposed at the end, length about 0·01 mm.

Nymph 3rd instar. Shape and colour as in the previous instar; devoid of any waxy fringe, dorsum minutely papillate, average measurements 0·77 × 0·58 mm. Marginal spines 17 pairs, the lateral cephalic and the anal prominent; dorsal and ventral spines as in the previous instar. Eyes entire; legs degenerate; antennae atrophied, directed inward and hooked at the tip, 0·03 mm. long. Vasiform orifice as in the previous instar.

Pupa. Broadly elliptical, 1·15 × 0·90 mm., greenish pale-yellow, submarginal area whitish, margin entire; devoid of waxy fringe, dorsum minutely papillate. Marginal spines 10–15 pairs—cephalic, caudo-lateral and anal being truly marginal and prominent, others minute, and slightly submarginal in position. Dorsal and ventral spines as in the previous instars. Caudal furrow prominent, showing cellular markings. Eyes well developed, legs and antennae as usual in this instar, the latter terminating in a small process and measuring about 0·08 mm. Vasiform orifice relatively small, almost semicircular, enclosed in a corresponding marginal area running close together, broader than long, inner lateral and caudal margins thickened, posterior half of the floor thickened by irregular, transverse ridges, average measurements 0·04 × 0·06 mm.; operculum similar in shape, cephalic margin straight, average measurements 0·02 × 0·03 mm.; lingula very small, almost entirely obscured by the operculum; length about 0·01 mm.

Adults. Male. Light-yellow, body without any sculpture, tip of rostrum brown; eyes constricted, facets sub-equal; wings white, spotless. Antennae concolorous with the body, seven segmented, about 0·32 mm. long, segment III the longest, IV the smallest from II to VII, VII longer than any from IV to VI; measurements of the antennal segments variable. Vasiform orifice transversely oval; operculum sub-quadrate, about 0·02 mm., caudal margin hairy; lingula long and broad, and about 0·02 mm. long. Parameres long and stout, length about 0·16 mm.; two teeth-like prominences sub-apically, the distal one narrower apically and the proximal one slightly broader at the apex and provided with a small hair; aedeagus shorter than the parameres.

Female. Concolorous with the male, to which it agrees in general characters. Antennae about 0·40 mm., segmental measurements variable, and occasionally segment V may be longer than VII. Genitalia as usual.

Tetralicia ericae Harrison 1917 (fig. 1).

Harrison (1917) described briefly the adult, larva and the pupa of this species and included it in *Tetralicia*. Baker and Moles (1921) and Singh (1931) included this genus in their classification.

I have not been able to collect an adult, although large quantities of heather (*Erica tetralix*) were examined from Hindhead, Surrey, and Wheathampstead, Herts. A few specimens of nymphs and pupae, however, were collected and their descriptions added since Harrison and subsequent authors did not describe these stages in detail.

Nymph 2nd instar. Elongated but slightly narrower at the extremities. Colour dark,[9] margins slightly deflexed ventrally; measurements about 0·46 × 0·20 mm. Abdominal segmentation distinct; mounted specimens show a series of star-shaped corrugated structures on either side of the median line (these might be some protuberances on the dorsal surface). Marginal spines three pairs—cephalic, caudo-lateral and anal, and a series of 5 or 6 minute submarginal spines. There are some minute circular pores towards the ends of the intersegmental partitions. Two pairs of dorsal spines—antennal and vasiformal. Legs degenerate; antennae atrophied, directed backwards. Vasiform

[9] Harrison described the colour of the larva as transparent but whitish. This was probably the case of a newly moulted nymph.

orifice almost circular, about 0·04 × 0·04 mm.; with a corresponding fold-like boundary outside, inner margins thickened all round; operculum subcordate, filling almost the entire orifice, measuring about 0·03 × 0·03 mm.; lingula small, a little knobbed distally, obscured by the operculum, length about 0·02 mm.

Nymph 3rd instar. Corresponds with the previous instar, in shape, structure and colour, measurements about 0·68 × 0·29 mm. The submarginal spines not prominent, segmental star-shaped structures quite distinct. Legs degenerate, antennae minute, narrower distally and directed inward, about 0·01 mm. Structure of the vasiform orifice as in the previous instar, measurements about 0·04 × 0·04 mm.; operculum, slightly notched inwards on the lateral margins, measures about 0·03 × 0·03 mm.; lingula, entirely obscured by the operculum, length about 0·02 mm.

Pupa. Elongated, narrower at both ends, about 1·03 × 0·56 mm.; margin deflexed, submarginal area smooth. Colour black.[10] A median row of circular areas in abdominal region. Legs and antennae as usual in the instar, the latter without terminal process, length about 0·07 mm. Vasiform orifice almost circular, enclosed within a concentric area, inner margins very much thickened, the lateral ones with a series of broad and blunt teeth, measurements about 0·06 × 0·05 mm.; operculum 0·04 × 0·04 mm.; lingula entirely obscured by the operculum, length 0·03 mm.

Trialeurodes vaporariorum (Westwood 1856) (fig. 7) and *T. sonchi* Kotinsky 1907 (fig. 7).

T. vaporariorum is a widely spread species and therefore it has already received considerable attention, particularly in relation to glass-house horticulture. Westwood (1856) described the species and mentioned its food-plants. Hargreaves (1915) published an account of its structure and biology. Lloyd (1922) supplemented this by giving its habits and methods of control, while Weber (1935) contributed to its morphology.

T. sonchi was originally described by Kotinsky (1907). Lloyd (1922) recorded it from greenhouses in England in association with the former species. Deshpande (1933) added a brief description of all stages.

Present Observations.

Two types of pupae were met with in greenhouses—(1) with 5–8 pairs of dorsal wax tubes and relatively shorter marginal wax processes, (2) without the dorsal wax tubes but with relatively longer marginal wax processes. This second type was identified by Mr. F. Laing as *T. sonchi* (vide Lloyd 1922). The pupae with the dorsal wax tubes (typical *T. vaporariorum*) have been found mostly associated with the hairy leaves particularly of *Nicotiana tabacum*, and *Nicotiana glutinosa*, while the other type was specially very common on the smooth leaves of *Nicotiana glauca*, even when these plants were in the same greenhouse.

The pupae of both types were also met with on hollyhock (*Althea rosea*) in nature as previously recorded by Lloyd. In one case on 5.xi.1936, *T. vaporariorum* was found breeding on a wild plant *Solanum dulcamara*, in the fields at Batford, Herts, far removed from greenhouses.

The pupae collected from *Sonchus* sp. in the field were without the dorsal wax tubes as stated by Deshpande (1933) but in general structure they corresponded with those of the other type.

The adults are practically identical, except that sometimes those of *T. vaporariorum* are uniformly yellow in colour. It is, however, not possible

[10] The descriptions of the stages given above are based on mounted specimens after bleaching.

to express an opinion on the adults from both types of pupae. The adults from *Sonchus* sp. and those bred from the pupae had invariably grey antennae, legs and the abdominal end. In two cases only the males from *Sonchus* sp. showed slightly different genitalia (fig. 7), in which case the parameres were longer than in the other form (fig. 7) and the aedeagus was also relatively smaller in relation to the parameres. It seems probable that adults with genitalia differing from the typical forms represent the species *T. sonchi*.

Aleyrodes fragariae Walker 1852.

The distinctiveness of this species seems a little doubtful. The specimens of the adults collected from strawberries locally, as well as those received from Dr. Massee from East Malling, yielded mixed individuals of *A. proletella* and *A. lonicerae*.

It was possible to breed both these species on strawberries in the laboratory as already described, but no immature stages were collected from this plant in nature.

The conclusive evidence to doubt the significance of this species was obtained from the breeding experiments with the adults received from Dr. Massee on 23.ix.1937. The progeny of the overwintering females was a mixed population of the yellow and grey individuals in the beginning of May 1938, and then of entirely yellow ones towards its latter half.

Since these adults behaved exactly as those of *A. lonicerae* in the laboratory, it is possible that the same species may have a wider range of food-plants. However, in the absence of any immature stages in the field on strawberries it is not justifiable to express an opinion in this respect.

List of British species of Aleyrodidae.

According to the present investigations, the following is the list of the species of Aleyrodidae known from, or suspected to exist in, Great Britain :—

(A) *Examined during the present investigations.*

(1) *Aleyrodes proletella* Linn. = (*brassicae* Walker).
(2) *Aleyrodes lonicerae* Walker = (*rubi* Signoret).
(3) *Aleyrodes fragariae* Walker—Doubtful.
(4) *Asterobemisia carpini* Koch = (*rubicola* Douglas).
(5) *Pealius quercus* Signoret = (*avellanae* Signoret).
(6) *Siphoninus phillyreae* Haliday.
(7) *Siphoninus immaculata* Heeger.
(8) *Dialeurodes chittendeni* Laing (Note 1).
(9) *Tetralicia ericae* Harrison.
(10) *Trialeurodes vaporariorum* Westwood (Note 2).
(11) *Trialeurodes sonchi* Kotinsky (Note 2).
(12) *Trialeurodes williamsi* Trehan (Note 2).
(13) *Aleuroplatus kewensis* Trehan (Note 2).

(B) *Not seen during the present investigations.*

(14) *Aleyrodes ribium* Douglas.
(15) *Aleyrodes spiraeae* Douglas.
(16) *Aleyrodes filicium* Goeldi (Note 3).
(17) *Aleyrodes azaleae* Baker and Moles (Note 4).

Notes.

(1) Introduced species now found out-of-doors on rhododendrons.
(2) Introduced species found in greenhouses; *T. vaporariorum* occasionally survives the summer out-of-doors, but not, so far as I know, the winter.
(3) Reported from ferns at Kew by Douglas but probably a misidentification.
(4) Taken on imported azaleas in a greenhouse near Edinburgh by V. G. Deshpande in November 1930 (unpublished thesis in the Library of the University of Edinburgh).

Key for identification of the species studied.

Pupae.

I. *Elevated from the leaf surface.*

A. Highly elevated, box-shaped, outer wall of wax conspicuous.

1. Hazel colour; vasiform orifice almost rounded, inner margins thickened, caudal portion showing foam-like chambers; operculum sub-rectangular, cephalic margin removed from that of the orifice.

Dorsal wax tubes present in large number.

i. Dorsum with tufts of white waxy material, operculum and lingula small, the latter knobbed at the end and without prominent terminal hairs, lingula extending to about the middle of orifice . . . . . *S. phillyreae.*
ii. Dorsum without tufts of white waxy material, operculum and lingula relatively large, lingula knobbed distally and with a pair of long prominent hairs at the tip and extending to about $\frac{2}{3}$ of the orifice . . . . . *S. immaculata.*

2. Whitish in colour, series of marginal wax processes, vasiform orifice subcordate, inner lateral margins toothed, operculum semicircular, cephalic margin almost conjointly parallel to that of the orifice, lingula lobed distally and armed with a pair of prominent hairs at the tip.

i. Dorsum with about 5–8 pairs of dorsal wax tubes, marginal wax processes relatively small . . . . . *T. vaporariorum.*
ii. Dorsum without any dorsal wax tubes, marginal wax processes relatively long . . . . . *T. sonchi.*

B. Slightly elevated, enclosed in a closely fitting wall of wax.

i. Greenish-yellow, 26–32 crescent-shaped submarginal papillae, giving rise to tape-like waxy tubes, a pair at each extremity relatively longer and prominent. Tracheal folds ending in a comb of 3 or 4 teeth; vasiform orifice subcordate, cephalic margin rounded and posteriorly a prominent caudal furrow, lingula lobed, $\frac{2}{3}$ of the lobed end exposed . . . . . *T. williamsi.*
ii. Yellowish-opaque, margin with a slightly raised ridge all round, abdominal segments with concolorous warts on either side of the median line, submarginal area broad and punctated; vasiform orifice in a depression which is ribbed transversely, orifice relatively small, sub-rectangular; lingula small and knobbed . . *P. quercus.*

II. *Not elevated from the leaf surface.*

A. Tracheal folds not evident on the margin.

1. Dorsum convex.

a. Sides fixed to the leaf by a border of wax.

i. Yellow or dark brown; vasiform orifice subcordate, inner lateral and caudal margins uniformly thickened, lingula spatulate with a pair of long hairs at the tip, about half exposed . . *A. proletella.*

ii. White, yellow or golden, abdominal region with concolorous circular areas on the median line; vasiform orifice subcordate, inner lateral margins toothed, lingula spatulate, relatively broader towards the caudal half and with a pair of long terminal hairs *A. lonicerae.*

b. Sides fixed to the leaf without a border of wax.

i. Yellowish-white, dorsum with minute papillae; caudal furrow with cellular markings; vasiform orifice semicircular, inner lateral and caudal margins thickened, posterior half of the floor with irregularly transverse ridges; operculum similar, lingula small, just the tip visible . . . . . *D. chittendeni.*

2. Dorsum deflexed.

i. Black, vasiform orifice circular, surrounded by a similar area, inner lateral margins thickened with a series of broad teeth, lingula entirely obscured by the operculum . . . . . *T. ericae.*

B. Tracheal folds evident and ending in a comb of teeth.

i. Whitish-opaque, outline of developing insect marked by an *oval* formed by concolorous warts; vasiform orifice long and triangular, inner lateral margins toothed, operculum semicircular, lingula long, thick and spatulate, with a pair of long hairs at the tip and more than half exposed . . . . . *Asterobemisia carpini.*

ii. Yellow, dorsum with a low keel in the median cephalic and thoracic region; vasiform orifice elevated and bounded by brownish ridges, sub-circular, inner row of striations prominent, operculum large, lingula stout, inverted half-opened mushroom-shaped, head spinous and with a pair of stoutish hairs at the tip, the head almost exposed . . . . . *Aleuroplatus kewensis.*

Adults.

I. *Wings spotted.*

1. Fore-wings with two grey spots.

Adults spotted with brown on head and thorax, transverse bands on the dorsum of the abdomen; operculum sub-rectangular, lingula long and thick, hairy at the tip; aedeagus angularly bent, parameres with an outgrowth sub-apically . . . . . *A. proletella.*

2. Fore-wings with one grey spot.

Adults pure yellow or spotted with brown at the head, thorax and legs, etc., also the genitalia grey, operculum notched at the caudal margin, lingula long, aedeagus slightly curved; parameres with a heel-shaped structure sub-apically . . . . . *A. lonicerae.*

II. *Wings spotless.*

1. Fore-wings slightly smoky towards the blade; body with a mixture of grey and yellow; operculum rectangular, lingula long and tapering distally, may be slightly bent; aedeagus with a pair of hooks at the tip; parameres long and stout, each with a sub-apical tooth . . . . *S. phillyreae.*

2. Wings clear.

   i. Adults pure yellow; operculum rectangular, lingula long and broad and appears as if two-segmented, parameres long and stout, each with a sub-apical ridge on the ventral side; aedeagus with a papilla-like outgrowth at the tip . . . . . *S. immaculata.*

   ii. Adults yellow; operculum quadrate, lingula long and uniformly broad, aedeagus almost straight, parameres long and stout, each with two sub-apical inner teeth-like prominences, the distal one narrower apically and the proximal one slightly broader and with a hair at the apex . . . . . *D. chittendeni.*

   iii. Adults yellow, operculum sub-rectangular, lingula small, narrower towards the tip; aedeagus relatively long, reaching near the tip of the parameres; parameres small, and deeply forked at the tip *P. quercus.*

   iv. Adults yellow, operculum notched at the caudal margin, lingula small and broad, rounded at the tip, parameres medium *Asterobemisia carpini.*

   v. Adults yellow; operculum rectangular, lingula small, broader at the tip, parameres small, rounded at the apex and provided with a claw-shaped structure at the tip . . . . . *T. williamsi.*

   vi. Adults yellow; operculum transverse, arched at the caudal margin, lingula long, narrow and with a few hairs at the tip, parameres small, with an inner row of seven teeth increasing in size distally *Aleuroplatus kewensis.*

   vii. Adults yellow or with the distal part of antennae, abdominal end and legs grey, operculum transverse, lingula long, slightly broader at the tip, parameres medium, aedeagus relatively long and reaching near the tip of the parameres . . . . . *T. vaporariorum.*

   viii. Adults yellow with distal part of antennae, legs and abdominal end grey, operculum and lingula as above, parameres relatively long with bent tips and aedeagus smaller than the parameres . *T. sonchi.*

Parasites recorded.

The following is the list[11] of the parasites bred from the pupae of the respective hosts collected in the field :—

Parasite	Host
Encarsia partenopea Masi.	*S. phillyreae* and *S. immaculata.*
Aleurodiphagus? *clavicornis* Thoms.	*A. lonicerae*, *A. rubi*[12] and *A. carpini.*
Isostasius sp.	*A. carpini.*
Eretmocerus sp.	*A. carpini.*
Encarsia formosa Gahn.	*T. vaporariorum.*
Prospeltella sp.?	*T. williamsi*
Eretmocerus corni Hald.	*P. quercus.*

[11] The parasites were kindly identified by Dr. Ch. Ferrière of the British Museum (Natural History).

[12] Pupae of *A. lonicerae* type collected from blackberry.

Parasitisation in nature was studied in three species : namely, *S. phillyreae*, *S. immaculata* and *A. carpini*, and the following observations were made :—

(1) *S. phillyreae.*

A. John Innes Institution, Merton (Surrey).

(i) May 1937. Out of 225 pupae examined, 38 were found parasitised.
(ii) June 1937. Out of 65 pupae 23 were found parasitised.

Average parasitisation, therefore, was 21%.

B. Camberley (Surrey).

(i) September 1937. Out of 141 pupae examined, 53 were found parasitised.
Percentage of parasitisation was 37·6%.

Average percentage of parasitisation in the species from both the localities was 26·5%.

(2) *S. immaculata.*

Batford (Herts).

(i) February 1937. Out of a total of 250 pupae and pupae cases, 72 were found parasitised. This gave 28·8% parasitisation.

From both these species *Encarsia parthenopea* Masi was bred out in the laboratory.

(3) *Asterobemisia carpini.*

Batford (Herts).

(i) April 1937. Out of 42 pupae examined, 15 were found parasitised.
(ii) May 1937. Out of 51 pupae 22 were parasitised.

Average parasitisation, therefore, was 39·8%.

(iii) March 1938. 16 parasitised out of 39 pupae.
(iv) April 1938. 19 parasitised out of 47 pupae.
(v) May 1938. 13 parasitised out of 33 pupae.

Average parasitisation 40·3%.

Average parasitisation from two years' observations, therefore, comes to 40·1%. The species of the parasites bred out from these collections are given in the list.

Oviposition. This was studied in *Encarsia partenopea*, under a binocular and the following observations made :—

The parasite surveyed the host thoroughly with the help of its antennae, which worked very briskly during the act. When satisfied about the host and the proper position, the parasite balanced its body on its legs, shot out the ovipositor and inserted it in the host. The insertion is generally very deep and the body of the parasite often rests on that of the host when penetration has taken place. During this stage the antennae were stationary and bent almost at right angles to the head. The duration of the act varied each time. In four cases under observation, the duration varied from 1·5 minutes to 9 minutes with an average duration (from 48 observations) of about 4 minutes and 52 seconds.

The parasite repeated these operations very frequently, one following the other, but after a few stings it often rested a while before starting again.

In one case the parasite was noticed working its mouth-parts on the puncture made by the ovipositor, and took about 19 minutes over it. This, however, is not a common practice, as also stated by Imms (1916), and it is quite probable that the parasite utilises the fluid that oozes out of the puncture, when a feed is required.

During these observations a parasite was observed to puncture the same pupa in three different places, but in no case did more than one parasite emerge from a parasitised pupa. Further, it has also been observed that, when a full-developed pupa was punctured by a parasite, the adult of the host white-fly emerged out invariably. Hence it proved that mere puncturing did not result in killing the developing host. This does not agree with Speyer (1927).

Life-cycle and transfers of some of the parasites from one host to the other.

Attempts were made to breed the parasites in the laboratory with a view to finding out the possibility of some interrelation of parasites with hosts other than those specific to them. The results of these observations are given in Table IX. These trials proved successful only with the parasites from *S. phillyreae* (*Encarsia partenopea* Masi) and *T. vaporariorum* (*Encarsia formosa* Gahn.) which bred readily on *A. proletella*. This Aleyrodid, therefore, may be considered a most suitable host for the interbreeding of these parasites. Speyer (1927) stated that the normal life-cycle in *E. formosa* did not take fewer than 28 days. The present observations support this.

TABLE IX.

Life-cycle and transfers of some of the parasites of white-flies from one host to the other.

Date.	From	On	Duration of life-cycle in days	Remarks.
1937				
16.v.	*A. carpini*	*A. carpini*	38–46	Successful.
25.v.	*S. phillyreae*	*A. carpini*	—	Not successful.
25.v.	*S. phillyreae*	*T. vaporariorum*	—	Not successful.
29.v.	*S. phillyreae*	*T. vaporariorum*	—	Not successful.
29.v.	*S. phillyreae*	*T. vaporariorum*	—	Not successful.
25.vi.	*A. carpini*	*A. proletella*	—	Not successful.
25.vi.	*A. carpini*	*A. proletella*	—	Not successful.
30.vi.	*A. carpini*	*A. proletella*	—	Not successful.
2.vii.	*S. phillyreae*	*T. vaporariorum*	—	Not successful.
13.viii.	*S. phillyreae*	*A. proletella*	30–36	Successful.
14.viii.	*S. phillyreae*	*T. vaporariorum*	—	Not successful.
22.viii.	*T. vaporariorum*	*T. vaporariorum*	33–40	Successful.
29.viii.	*T. vaporariorum*	*T. vaporariorum*	35–37	Successful.
29.viii.	*T. vaporariorum*	*A. proletella*	32–35	Successful.
7.ix.	*S. phillyreae*	*A. proletella*	31–33	Successful.
8.ix.	*S. phillyreae*	*A. proletella*	29–32	Successful.
7.ix.	*S. phillyreae*	*A. carpini* & *A. lonicerae*	—	Not successful.
28.ix.	*A. lonicerae*	*T. vaporariorum*	—	Not successful.
1938				
?	*T. vaporariorum*	*A. lonicerae*	?	Successful.[1]

[1] During March and April 1938, a number of parasites of *T. vaporariorum* (*Encarsia formosa* Gahn.) were bred out from the pupae of *A. lonicerae* which were kept in a hot-house where *T. vaporariorum* and its parasites were also present.

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